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THE STUDY OF SOCIOLOGY.

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III.—Nature of the Social Science.

OUT of bricks, well burnt, hard, and sharp-angled, lying in heaps by his side, the bricklayer builds, even without mortar, a wall of some height that has considerable stability. With bricks made of bad materials, irregularly burnt, warped, cracked, and many of them broken, he cannot build a dry wall of the same height and stability. The dock-yard laborer, piling cannon-shot, is totally unable to make these spherical masses stand at all as the bricks stand. There are, indeed, certain quite definite shapes into which they may be piled—that of a tetrahedron, or that of a pyramid having a square base, or that of an elongated wedge allied to the pyramid. In any of these forms they may be put together symmetrically and stably; but not in forms with vertical sides or highly-inclined sides. Once more, if, instead of equal spherical shot, the masses to be piled are bowlders, partially but irregularly rounded, and of various sizes, no definite stable form is possible. A comparatively-loose heap, indefinite in its surfaces and angles, is all the laborer can make of them. Putting which several facts together, and asking what is the most general truth they imply, we see it to be this—that the character of the aggregate is determined by the characters of the units.

If we pass from units of these visible, tangible kinds, to the units contemplated by chemists and physicists as making up masses of matter, the same truth meets us. Each so-called element, each combination of elements, each recombination of the compounds, has a form of crystallization. Though its crystals differ in their sizes, and are liable to be modified by truncations of angles and apices, and by partially

merging into one another, yet the type of structure, as shown by cleavage, is constant: particular kinds of molecules severally have particular shapes into which they settle themselves as they aggregate. And though in some cases it happens that a substance, simple or compound, has two or even more forms of aggregation, yet the recognized interpretation is, that these different forms are the forms assumed by molecules made different in their structures by allotropic or isomeric changes. So constant is the relation between the nature of any molecules and their mode of crystallizing, that, given two kinds of molecules which are known, from their chemical actions, to be closely allied in their natures, and it is inferred with certainty that their crystals will be closely allied. In brief, it may be unhesitatingly affirmed, as an outcome of physics and chemistry, that throughout all phenomena presented by dead matter the natures of the units necessitate certain traits in the aggregates.

This truth is again exemplified by aggregates of organic matter. In the substance of each species of plant or animal, there is a proclivity toward the structure which that plant or animal presents—a proclivity conclusively proved in cases where the conditions to the maintenance of life are sufficiently simple, and where the tissue has not assumed a structure too finished to permit rearrangement. The perpetually-cited case of the polype, each part of which, when it is cut into several, presently puts on the polype-shape, and gains structures and powers like those of the original whole, illustrates this truth among animals. Among plants it is well exemplified by the Begonias. Here a complete plant grows from a fragment of a leaf stuck into the ground; and, in *Begonia phyllomaniaca*, complete plants grow even out of scales that fall from the leaves and the stem—a fact showing, like the fact which the polype furnishes, that the units everywhere present have for their type of aggregation the type of the organism they belong to; and reminding us of the universal fact that the units composing every germ, animal or vegetal, have a proclivity toward the parental type of aggregation.

Thus, given the natures of the units, and the nature of the aggregate they form is predetermined. I say the *nature*, meaning, of course, the essential traits, and not including the incidental. By the characters of the units are necessitated certain limits within which the characters of the aggregate must fall. The circumstances attending aggregation greatly modify the results; but the truth here to be recognized is, that these circumstances, in some cases perhaps preventing aggregation altogether, in other cases impeding it, in other cases facilitating it more or less, can never give, to the aggregate, characters that do not consist with the characters of the units. No favoring conditions will give the laborer power to pile cannon-shot into a vertical wall; no favoring conditions will make it possible for common salt, which crystallizes on the regular system, to crystallize, like sulphate of soda, on

the oblique prismatic system; no favoring conditions will enable the fragment of a polype to take on the structure of a mollusk.

Among such social aggregates as inferior creatures fall into, more or less definitely, the same truth holds. Whether they live in a mere assemblage, or whether they live in something like an organized union, with division of labor among its members, as happens in many cases, is unquestionably determined by the properties of the units. Given the structures and consequent instincts of the individuals as we find them, and the community they form will inevitably present certain traits; and no community having such traits can be formed out of individuals having other structures and instincts.

Those who have been brought up in the belief that there is one law for the rest of the universe and another law for mankind, will doubtless be astonished by the proposal to include aggregates of men in this generalization. And yet that the properties of the units determine the properties of the whole they make up, evidently holds of societies as of other things. A general survey of tribes and nations, past and present, shows clearly enough that it is so; and a brief consideration of the conditions shows, with no less clearness, that it must be so.

Ignoring for the moment the special traits of races and individuals, observe the traits common to members of the species at large; and consider how these must affect their relations when associated.

They have all needs for food, and have corresponding desires. To all of them exertion is a physiological expense; must bring a certain return in nutriment, if it is not to be detrimental; and is accompanied by repugnance when pushed beyond this limit, or even before reaching it. They are all of them liable to bodily injury, with accompanying pain, from various extreme physical actions; and they are liable to emotional pains, of positive and negative kinds, from one another's actions. As says Shylock, insisting on that human nature which Jews have in common with Christians:

> "Hath not a Jew eyes? hath not a Jew hands, organs, dimensions, senses, affections, passions? fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer, as a Christian is? If you prick us, do we not bleed? if you tickle us, do we not laugh? if you poison us, do we not die? and if you wrong us, shall we not revenge? If we are like you in the rest, we will resemble you in that."

Conspicuous, however, as is this possession of certain fundamental qualities by all individuals, there is no adequate recognition of the truth that from these individual qualities must result certain qualities in an assemblage of individuals; that in proportion as the individuals forming one assemblage are like in their qualities to the individuals forming another assemblage, the two assemblages will have likenesses;

and that the assemblages will differ in their characters in proportion as the component individuals of the one differ from those of the other. Yet when this, which is almost a truism, has been admitted, it cannot be denied that in every community there is a group of phenomena growing naturally out of the phenomena presented by its members—a set of properties in the aggregate determined by the sets of properties in the units; and that the relations of the two sets form the subject-matter of a science. It needs but to ask what would happen if men avoided one another, as various inferior creatures do, to see that the very possibility of a society depends on a certain emotional property in the individual. It needs but to ask what would happen if each man liked best the men who gave him most pain, to perceive that social relations, supposing them to be possible, would be utterly unlike the social relations resulting from the greater liking which men individually have for others who give them pleasure. It needs but to ask what would happen if, instead of ordinarily preferring the easiest ways of achieving their ends, men preferred to achieve their ends in the most troublesome ways, to infer that, then, a society, if one could exist, would be a widely-different society from any we know. And if, as these extreme cases show us, cardinal traits in societies are determined by cardinal traits in men, it cannot be questioned that less-marked traits in societies are determined by less-marked traits in men; and that there must everywhere be a *consensus* between the special structures and actions of the one and the special structures and actions of the other.

Setting out, then, with this general principle, that the properties of the units determine the properties of the aggregate, we conclude that there must be a Social Science expressing the relations between the two with as much definiteness as the natures of the phenomena permit. Beginning with types of men who form but small and incoherent social aggregates, such a science has to show in what ways the individual qualities, intellectual and emotional, negative further aggregation. It has to explain how slight modifications of individual nature, arising under modified conditions of life, make somewhat larger aggregates possible. It has to trace out, in aggregates of some size, the genesis of the social relations, regulative and operative, into which the members fall. It has to exhibit the stronger and more prolonged social influences which, by further modifying the characters of the units, facilitate further aggregation with consequent further complexity of social structure. Among societies of all orders and sizes, from the smallest and rudest up to the largest and most civilized, it has to ascertain what traits there are in common, determined by the common traits of human beings; what less-general traits, distinguishing certain groups of societies, result from traits distinguishing certain races of men; and what peculiarities in each society are traceable to the peculiarities of its members. In every case it has for its subject-matter the growth, de-

velopment, structure, and functions of the social aggregate, as brought about by the mutual actions of individuals whose natures are partly like those of all men, partly like those of kindred races, partly distinctive.

These phenomena of social evolution have, of course, to be explained with due reference to the conditions each society is exposed to—the conditions furnished by its locality and by its relations to neighboring societies. Noting this merely to prevent possible misapprehensions, the fact which here concerns us is, not that the Social Science has these or those special characters, but that, given men having certain properties, and an aggregate of such men must have certain derivative properties which form the subject-matter of a science.

"But were we not told some pages back that, in societies, causes and effects are related in ways so involved that prevision is often impossible? Were we not warned against rashly taking measures for achieving this or that desideratum, regardless of the proofs, so abundantly supplied by the past, that agencies set in action habitually work out results never foreseen? And were not instances given of all-important changes that were due to influences from which no one would have anticipated them? If so, how can there be a Social Science? If Louis Napoleon could not have expected that the war he began to prevent the consolidation of Germany would be the very means of consolidating it; if to M. Thiers, five-and-twenty years ago, it would have seemed a dream, exceeding all ordinary dreams in absurdity, that he would be fired at from his own fortifications, how in the name of wonder is it possible to formulate social phenomena in any thing approaching scientific order?"

The difficulty, thus put in as strong a form as I can find for it, is that which, clearly or vaguely, rises in the minds of most to whom Sociology is proposed as a subject to be studied after scientific methods, with the expectation of reaching results having scientific certainty. Before giving to the question its special answer, let me give it a general answer.

The science of Mechanics has reached a development higher than has been reached by any but the purely abstract sciences. Though we may not call it perfect, yet the great accuracy of the predictions which its ascertained principles enable astronomers to make, shows how near to perfection it has come; and the achievements of the skilful artillery-officer prove that, in their applications to terrestrial motions, these principles yield previsions of considerable exactness. But now, taking Mechanics as the type of a highly-developed science, let us note what it enables us to predict, and what it does not enable us to predict, respecting some concrete phenomenon. Say that there is a mine to be exploded. Ask what will happen to the fragments of matter sent into the air. Then observe how much we can infer from estab-

lished dynamical laws. By that common observation which precedes the more exact observations of science, we are taught that all the fragments, having risen to heights more or less various, will fall; that they will reach the ground at scattered places within a circumscribed area and at somewhat different times. Science enables us to say more than this. From those same principles whence are inferable the path of a planet or a projectile, it deduces the truth that each fragment will describe a curve; that all the curves, though individually different, will be specifically alike; that (ignoring deviations caused by atmospheric resistance) they will severally be portions of ellipses so eccentric as to be indistinguishable from parabolas—such parts of them, at least, as are described after the rush of gases ceases further to accelerate the fragments. But, while the principles of Mechanics help us to these certainties, we cannot learn from them any thing more definite respecting the courses that will be taken by particular fragments. Whether, of the mass overlying the powder to be exploded, the part on the left will be propelled upward in one fragment or several? whether this piece will be shot higher than that? whether any, and, if so, which of the projected masses will be stopped in their courses by adjacent objects they strike?—are questions it cannot answer. *Not that there will be any want of conformity to law in these results*, but that the data, on which predictions of them are to be based, cannot be obtained.

Observe, then, that, respecting a concrete phenomenon of some complexity, the most exact science enables us to make predictions that are mainly general, or only partially special. Seeing that this is so, even where the causes and effects are not greatly involved, and where the science of them is well developed, much more may we expect it to be so among the most involved causes and effects, the science of which is but rudimentary. This contrast, between the generalities that admit of prevision and the specialties that do not admit of prevision, will be still more clearly seen on passing from this preliminary illustration to an illustration in which the analogy is closer.

What can we say about the future of this newly-born child? Will it die of some disorder during infancy? Will it survive awhile, and be carried off by scarlet fever or whooping-cough? Will it have measles or small-pox, and succumb to one or the other? None of these questions can be answered. Will it some day fall down-stairs, or be run over, or set fire to its clothes; and be killed or maimed by one or other of these accidents? These questions also have no answers. None can tell whether in boyhood there may come epilepsy, or St. Vitus's dance, or other formidable affection. Looking at the child now in the nurse's arms, none can foresee with certainty that it will be stupid or intelligent, tractable or perverse. Equally beyond possibility of prediction are those events which, if it survives, will occur to it in maturity—partly caused by its own nature, and partly

by surrounding conditions. Whether there will come the success due to skill and perseverance; whether the circumstances will be such as to give these scope or not; whether accidents will thwart or favor efforts—are wholly unanswerable inquiries. That is to say, the facts we ordinarily class as biographical do not admit of prevision.

If, from quite special facts, we turn to facts of a somewhat less special kind which the life of this infant will present, we find, among those that are *quasi*-biographical, a certain degree of prevision possible. Though the unfolding of the faculties is variable within limits, going on here precociously and there with unusual slowness, yet there is such order in the unfolding as enables us to say that the child will not be a mathematician or a dramatist at three years old, will not be a psychologist by the time he is ten, will not reach extended political conceptions while his voice is still unbroken. Moreover, of the emotional nature we may make certain predictions of a kindred order. Whether he will marry or not, no one can say; but it is possible to say, if not with certainty still with much probability, that after a certain age an inclination to marry will arise; and though none can tell whether he will have children, yet that, if he has, some amount of the paternal feeling will be manifested, may be concluded as very likely.

But now, if looking at the entire assemblage of facts that will be presented during the life of this infant as it becomes mature, decays, and dies, we pass over the biographical and *quasi*-biographical, as admitting of either no prevision or but imperfect prevision; we find remaining classes of facts that may be asserted beforehand: some with a high degree of probability, and some with certainty—some with great definiteness and some within moderate limits of variation. I refer to the facts of growth, development, structure, and function.

Along with that love of personalities which exalts every thing inconstant in human life into a matter of interest, there goes the habit of regarding whatever is constant in human life as a matter of no interest; and so, when contemplating the future of the infant, there is a tacit ignoring of all the vital phenomena it will exhibit—phenomena that are alike knowable and important to be known. The anatomy and physiology of Man, comprehending under these names not only the structures and functions of the adult, but the progressive establishment of these structures and functions during individual evolution, form the subject-matter of what every one recognizes as a science. Though there is imperfect exactness in the generalized coexistences and sequences making up this science; though general truths respecting structures are met by occasional exceptions in the way of malformations; though anomalies of function also occur to negative absolute prediction; though there are considerable variations of the limits within which growth and structure may range, and considerable differences between the rates of functions and between the times at which functions are established; yet no one doubts that the biological phe-

nomena presented by the human body may be organized into a knowledge having the definiteness which constitutes it scientific, in the understood sense of that word.

If, now, any one, insisting on the incalculableness of a child's future, biographically considered, asserted that the child, therefore, presented no subject-matter for science, ignoring altogether what we will for the moment call its anthropology (though the meaning now given to the word scarcely permits this use of it), he would fall into a conspicuous error—an error in this case made conspicuous because we are able daily to observe the difference between an account of the living body, and an account of its conduct and the events that occur to it.

The reader doubtless anticipates the analogy. What Biography is to Anthropology, History is to Sociology—History, I mean, as commonly conceived. The kind of relation which the sayings and doings, that make up the ordinary account of a man's life, bear to an account of his bodily and mental evolution, structural and functional, is like the kind of relation borne by that narrative of a nation's actions and fortunes its historian gives us, to a description of its institutions, regulative and operative, and the ways in which their structures and functions have gradually established themselves. And if it is an error to say that there is no Science of Man, because the events of a man's life cannot be foreseen, it is equally an error to say that there is no Science of Society, because there can be no prevision of the occurrences which make up ordinary history.

Of course, I do not say that the parallel between an individual organism and a social organism is so close that the distinction to be clearly drawn in the one case may be drawn with like clearness in the other. The structures and functions of the social organism are obviously far less specific, far more modifiable, far more dependent on conditions that are variable and never twice alike. All I mean is that, as in the one case so in the other, there lie underneath the phenomena of conduct, not forming subject-matter for science, certain vital phenomena, which do form subject-matter for science. Just as in the man there are structures and functions which make possible the doings his biographer tells of, so in the nation there are structures and functions which make possible the doings its historian tells of; and in both cases it is with these structures and functions, in their origin, development, and decline, that science is concerned.

To make better the parallel, and further to explain the nature of the Social Science, we must say that the morphology and physiology of Society, instead of corresponding to the morphology and physiology of Man, correspond rather to morphology and physiology in general. Social organisms, like individual organisms, are to be arranged into classes and sub-classes—not, indeed, into classes and sub-classes having

any thing like the same definiteness or the same constancy, but nevertheless having likenesses and differences which justify the putting of them into major groups most markedly contrasted, and, within these, arranging them in minor groups less markedly contrasted. And just as Biology discovers certain general traits of development, structure, and function, holding throughout all organisms, others holding throughout certain great groups, others throughout certain sub-groups these contain; so Sociology has to recognize truths of social development, structure, and function, that are some of them universal, some of them general, some of them special.

For, recalling the conclusion previously reached, it is manifest that, in so far as human beings, considered as social units, have properties in common, the social aggregates they form will have properties in common; that likenesses of nature holding throughout certain of the human races, will originate likenesses of nature, in the nations arising out of them; and that such peculiar traits as are possessed by the highest varieties of men must result in distinctive characters possessed in common by the communities into which they organize themselves.

So that, whether we look at the matter in the abstract or in the concrete, we reach the same conclusion. We need but to glance, on the one hand, at the varieties of uncivilized men and the structures of their tribes, and, on the other hand, at the varieties of civilized men and the structures of their nations, to see inference verified by fact. And thus recognizing, both *a priori* and *a posteriori*, these relations between the phenomena of individual human nature and the phenomena of incorporated human nature, we cannot fail to see that the phenomena of incorporated human nature form the subject-matter of a science.

And now to make more definite the conception of a Social Science thus shadowed forth in a general way, let me set down a few truths of the kind indicated. Some that I propose to name are very familiar; and others I add, not because of their interest or importance, but because they are easy of exposition. The aim is simply to convey a clear idea of the nature of sociological truths.

Take, first, the general fact that along with social aggregation there always goes some kind of organization. In the very lowest stages, where the assemblages are very small and very incoherent, there is no established subordination—no centre of control. Chieftainships of settled kinds come only along with larger and more coherent aggregates. The evolution of a governmental structure, having some strength and permanence, is the condition under which alone any considerable growth of a society can take place. A differentiation of the originally homogeneous mass of units, into a coördinating part and coördinated part, is the indispensable initial step.

Along with evolution of societies in size there goes evolution of their coördinating centres; which, having become permanent, presently become more or less complex. In small tribes, chieftainship, generally wanting in stability, is quite simple; but, as tribes become larger by growth, or by reduction of other tribes to subjection, the coordinating apparatus begins to develop by the addition of subordinate governing agencies.

Simple and familiar as are these facts, we are not, therefore, to overlook their significance. That men rise into the state of social aggregation only on condition that they lapse into relations of inequality in respect of power, and are made to coöperate as a whole only by the agency of a structure securing obedience, is none the less a fact in science because it is a trite fact. This is a primary common trait in social aggregates derived from a common trait in their units. It is a truth in Sociology, comparable to the biological truth, that the first step in the production of any living organism, high or low, is a certain differentiation, whereby a peripheral portion becomes distinguished from a central portion. And such exceptions to this biological truth as we find in those minute non-nucleated portions of protoplasm that are the very lowest living things, are paralleled by those exceptions to the sociological truth, seen in the small incoherent assemblages formed by the very lowest types of men.

The differentiation of the regulating part and the regulated part is, in small primitive societies, not only imperfectly established but vague. The chief does not at first become unlike his fellow-savages in his functions, otherwise than by exercising greater sway. He hunts, makes his weapons, works, and manages his private affairs, in just the same ways as the rest; while in war he differs from other warriors only by his predominant influence, not by ceasing to be a private soldier. And, along with this slight separation from the rest of the tribe in military functions and industrial functions, there is only a slight separation politically: judicial action is but very feebly represented by exercise of his personal authority in keeping order.

At a higher stage, the power of the chief being well established, he no longer supports himself. Still he remains undistinguished industrially from other members of the dominant class, which has grown up while chieftainship has been getting settled; for he simply gets productive work done by deputy, as they do. Nor is a further extension of his power accompanied by complete separation of the political from the industrial functions; for he habitually remains a regulator of production, and in many cases a regulator of trade, presiding over acts of exchange. Of his several controlling functions, this last is, however, the one which he first ceases personally to carry on. Industry early shows a tendency toward self-control, apart from the control which the chief exercises more and more as political and military head. The primary social differentiation which we have noted between the regu-

lative part and the operative part is presently followed by a distinction, which eventually becomes very marked, between the internal arrangements of the two parts: the operative part slowly developing within itself agencies by which processes of production, distribution, and exchange are coördinated, while coördination of the non-operative part continues on its original footing.

Along with a development which renders conspicuous the separation of the operative and regulative structures, there goes a development within the regulative structures themselves. The chief, at first uniting the characters of king, judge, captain, and often priest, has his functions more and more specialized as the evolution of the society in size and complexity advances. While remaining supreme judge, he does most of his judging by deputy; while remaining nominally head of his army, the actual leading of it falls more and more into the hands of subordinate officers; while still retaining ecclesiastical supremacy, his priestly functions practically almost cease; while in theory the maker and administrator of the law, the actual making and administration lapse more and more into other hands. So that, stating the facts broadly, out of the original coördinating agent having undivided functions, there eventually develop several coördinating agencies which divide these functions among them.

Each of these agencies, too, follows the same law. Originally simple, it step by step subdivides into many parts, and becomes an organization, administrative, judicial, ecclesiastical, or military, having graduated classes within itself, and a more or less distinct form of government within itself.

I will not complicate this statement by doing more than recognizing the variations that occur in cases where supreme power does not lapse into the hands of one man (which, however, in early stages of social evolution is an unstable modification). And I must explain that the above general statements are to be taken with the qualification that differences of detail are passed over to gain brevity and clearness. Add to which that it is beside the purpose of the argument to carry the description beyond these first stages. But duly bearing in mind that, without here elaborating a Science of Sociology, nothing more than a rude outline of cardinal facts can be given, enough has been said to show that, in the development of social structures, there may be recognized certain most general facts, certain less general facts, and certain facts successively more special; just as there may be recognized general and special facts of evolution in individual organisms.

To extend, as well as to make clearer, this conception of the Social Science, let me here set down a question which comes within its sphere. What is the relation in a society between structure and growth? Up to what point is structure necessary to growth? after what point does it retard growth? at what point does it arrest growth?

There exists in the individual organism a duplex relation between growth and structure which it is difficult adequately to express. Excluding the cases of a few low organisms living under special conditions, we may properly say that great growth is not possible without high structure. The whole animal kingdom, throughout its invertebrate and vertebrate types, may be cited in evidence. On the other hand, among the superior organisms, and especially among those leading active lives, there is a marked tendency for completion of structure to go along with the arrest of growth. While an animal of elevated type is growing rapidly, its organs continue imperfectly developed—the bones remain partially cartilaginous, the muscles are soft, the brain lacks definiteness; and the details of structure throughout all parts are finished only after growth has ceased. Why these relations are as we find them, it is not difficult to see. That a young animal may grow, it must digest, circulate blood, breathe, excrete waste products, and so forth; to do which it must have tolerably-complete viscera, vascular system, etc. That it may eventually become able to get its own food, it has to develop gradually the needful appliances and aptitudes; to which end it must begin with limbs, and senses, and nervous system, that have considerable degrees of efficiency. But, along with every increment of growth achieved by the help of these partially-developed structures, there has to go an alteration of the structures themselves. If they were rightly adjusted to the preceding smaller size, they are wrongly adjusted to the succeeding greater size. Hence, they must be remoulded—unbuilt and rebuilt. Manifestly, therefore, in proportion as the previous building has been complete, there arises a great obstacle in the shape of unbuilding and rebuilding. The case of the bones shows us how this difficulty is met by a compromise. In the thigh-bone of a boy, for instance, there exists, between the condyle, or head, and the cylindrical part of the bone, a place where the original cartilaginous state continues; and where, by the addition of new cartilage and new osseous matter, the shaft of the bone is lengthened: the like going on in an answering place at the other end of the shaft. Complete osssification at these two places occurs only when the bone has ceased to increase in length; and, on considering what would have happened had the bone been ossified from end to end before its growth was complete, it will be seen how great an obstacle to growth is thus escaped. What holds here, holds throughout the organism: though structure up to a certain point is requisite for further growth, structure beyond that point impedes growth. How necessary is this relation we shall equally perceive in a more complex case—say, the growth of an entire limb. There is a certain size and proportion of parts, which a limb ordinarily has in relation to the rest of the body. Throw upon that limb extra function, and within moderate limits it will increase in strength and bulk. If the extra function begins early in life, the limb may be raised considerably

above its usual size; but, if the extra function begins after maturity, the deviation is less: in either case, however, being great. If we consider how increase of the limb is effected, we shall see why this is so. More active function brings a greater local supply of blood; and, for a time, new tissue is formed in excess of waste. But the local supply of blood is limited by the sizes of the arteries which bring it; and though, up to a certain point, increase of flow is gained by temporary dilatation of them, yet beyond that point increase can be gained only by unbuilding and rebuilding the arteries. Such alterations of arteries slowly take place—less slowly with the smaller peripheral ones, more slowly with the larger ones out of which these branch; since these have to be altered all the way back to their points of divergence from the great central blood-vessels. In like manner, the channels for carrying off waste products must be remodelled, both locally and centrally. The nerve-trunks, too, and also the centres from which they come, must be adjusted to the greater demands upon them. Nay, more; with a given visceral system, a large extra quantity of blood cannot be permanently given to one part of the body, without decreasing the quantities given to other parts; and, therefore, structural changes have to be made by which the drafting-off of blood to these other parts is diminished. Hence, the great resistance to increase in the size of a limb beyond a certain moderate limit. Such increase cannot be effected without unbuilding and rebuilding not only the parts that directly minister to the limb, but, eventually, all the remoter parts. So that the bringing of structures into perfect fitness for certain requirements, immensely hinders the adaptation of them to other requirements—readjustments become difficult in proportion as adjustments are made complete.

How far does this law hold in the social organism? To what extent does it happen here, too, that the multiplying and elaborating of institutions, and the perfecting of arrangements for gaining immediate ends, raise impediments to the development of better institutions and to the future gaining of higher ends? Socially, as well as individually, organization is indispensable to growth: beyond a certain point there cannot be further growth without further organization. Yet there is not a little reason for suspecting that beyond this point organization is indirectly repressive—increases the obstacles to those readjustments required for larger growth and more perfect structure. Doubtless the aggregate we call a society is much more plastic than an individual living aggregate to which it is here compared—its type is far less fixed. Nevertheless, there is evidence that its type tends continually to become fixed, and that each addition to its structures is a step toward the fixation. A few instances will show how this is true alike of the material structures a society develops and of its institutions, political or other.

Cases, quite insignificant, perhaps, but quite to the point, are furnished by our appliances for locomotion. Not to dwell on the minor

ones within cities, which, however, show us that existing arrangements are impediments to better arrangements, let us pass to railways. Observe how the inconveniently-narrow gauge (which, taken from that of stage-coach wheels, was itself inherited from an antecedent system of locomotion) has become an insuperable obstacle to a better gauge. Observe, also, how the type of carriage, which was derived from the body of a stage-coach (some of the early first-class carriages bearing the words "*tria juncta in uno*"), having become established, it is immensely difficult now to introduce the more convenient type later established in America; where they profited by our experience, but were not hampered by our adopted plans. The enormous capital invested in our stock of carriages cannot be sacrificed. Gradually to introduce carriages of the American type, by running them along with those of our own type, would be very difficult, because of our many partings and joinings of trains. And thus we are obliged to go on with a type that is inferior.

Take, again, our system of drainage. Urged on as it was some 30 years ago as a panacea for sundry sanitary evils, and spread as it has been by force of law through all our great towns, this system can not now be replaced by a better system without immense difficulty. Though, by securing decomposition where oxygen cannot get, and so generating chemical compounds that are unstable and poisonous, it has in many cases produced the very diseases it was to have prevented; yet it has become almost out of the question now to adopt those methods by which the excreta of towns may be got rid of at once innocuously and usefully. Nay, worse—one part of our sanitary administration having insisted on a sewage-system by which Oxford, Reading, Maidenhead, Windsor, etc., pollute the water London has to drink, another part of our sanitary administration makes loud protests against the impurity of the water, which it charges with causing disease (not remarking, however, that law-enforced arrangements have produced the impurity). And now there must be a reorganization that will be immensely impeded by the existing premature organization, before we can have either pure air or pure water.

Our mercantile arrangements, again, furnish abundant illustrations teaching the same lesson. In each trade there is an established course of business; and, however obvious may be some better course, the difficulties of altering the settled routine are, if not insurmountable, still very considerable. Take, for instance, the commerce of literature. In days when a letter cost a shilling and no book-post existed, there grew up an organization of wholesalers and retailers to convey books from publishers to readers: a profit being reaped by each distributing agent, primary and secondary. Now that a book may be ordered for a half-penny and sent for a few pence, the old system of distribution might be replaced by one that would diminish the cost of transfer, and lower the prices of books. But the interests of distribu-

tors practically negative the change. An advertised proposal to supply a book direct by post, at a reduced rate, offends the trade; and by ignoring the book they check its sale more than its sale is otherwise furthered. And so an old organization once very serviceable now stands in the way of a better organization. The commerce of literature furnishes yet another illustration. At a time when the reading public was small and books were dear, there grew up circulating libraries, enabling people to read books without buying them. At first, few, local, and unorganized, these circulating libraries have greatly multiplied, and have become organized throughout the kingdom: the result being that the demand for library-circulation is in many cases the chief demand. This arrangement being one which makes few copies supply many readers, the price per copy must be high, to obtain an adequate return on the edition. And now reading people in general, having been brought up in the habit of getting books through libraries, they usually do not think of buying the books themselves—would still get most of them through libraries even were they considerably cheapened. We are, therefore, except with works of very popular authors, prevented, by the existing system of book-distribution in England, from adopting the American system—a system which, not adjusting itself to few libraries but to many private purchasers, issues large editions at low prices.

Instances of another class are supplied by our educational institutions. Richly endowed, strengthened by their *prestige*, and by the bias given to those they have brought up, our colleges, public schools, and other kindred schools early founded, useful as they once were, have long been enormous impediments to a higher education. By subsidizing the old, they have starved the new. Even now they are retarding a culture better in matter and manner; both by occupying the field, and by partially incapacitating those who pass through them for seeing what a better culture is. More evidence of a kindred kind is offered by the educational organization developed for dealing with the masses. The struggle going on between Secularism and Denominationalism in teaching might alone show to any one, who looks for the wider meanings of facts, that a structure which has ramified throughout a society, acquired an army of salaried officials looking for personal welfare and promotion, backed by classes, ecclesiastical and political, whose ideas and interests they further, is a structure which, if not unalterable, is difficult to alter in proportion as it is highly developed.

These few examples, which might be supported by others from the military organization, the ecclesiastical organization, the legal organization, will make comprehensible the analogy I have indicated; while they make clearer the nature of the Social Science, by bringing into view one of its questions. That with social organisms, as with individual organisms, structure up to a certain point is needful for growth

is obvious. That in the one case, as in the other, continued growth implies unbuilding and rebuilding of structure, which therefore becomes in so far an impediment, seems also obvious. Whether it is true in the one case, as in the other, that completion of structure involves arrest of growth, and fixes the society to the type it has then reached, is a question to be considered. Without saying any thing more by way of answer, it is, I think, manifest enough that this is one belonging to an order of questions entirely overlooked by those who contemplate societies from the ordinary historical point of view; and one pertaining to that Social Science which they say does not exist.

Are there any who utter the *cui bono* criticism? Probably not a few. I think I hear from some, whose mental attitude is familiar to me, the doubt whether it is worth while to ask what happens among savage tribes; in what way chiefs and medicine-men arise; how the industrial functions become separated from the political; what are the original relations of the regulative classes to one another; how far the social structure is determined by the emotional natures of individuals, how far by their ideas, how far by their environment. Busied as men of this stamp are with what they call "practical legislation" (by which they seemingly mean legislation that recognizes proximate causes and effects, while ignoring remote ones), they doubt whether conclusions, of the kind Social Science proposes to draw, are good for much when drawn.

Something may, however, be said in defence of this study which they thus estimate. Of course, it is not to be put on the same level with those historical studies so deeply interesting to them. The supreme value of knowledge respecting the genealogies of kings, and the fates of dynasties, and the quarrels of courts, is beyond question. Whether or not the plot for the murder of Amy Robsart was contrived by Leicester himself, with Queen Elizabeth as an accomplice; and whether or not the account of the Gowrie Conspiracy, as given by King James, was true; are obviously doubts to be decided before there can be formed any rational conclusions respecting the development of our political institutions. That Friedrich I. of Prussia quarrelled with his step-mother, suspected her of trying to poison him, fled to his aunt, and when he succeeded to the electorate intrigued and bribed to obtain his kingship; that, half an hour after his death, his son Friedrich Wilhelm gave his courtiers notice to quit, commenced forthwith to economize his revenues, made it his great object to recruit and drill his army, and presently began to hate and bully his son—these, and facts like these about all royal families in all ages, are facts without which the progress of civilization would be incomprehensible. Nor can one dispense with full knowledge of events like those of Napoleon's wars—his Italian conquests and exactions, and perfidious treatment of Venice; his expedition to Egypt, successes and massacres there, failure at Acre,

and eventual retreat; his various negotiations, alliances, treaties of peace and breaches of them; and so on with details of his various campaigns in Germany, Spain, Russia, etc., including accounts of his strategy, tactics, victories, defeats, slaughters, etc., etc.; for how, in the absence of such information, is it possible to judge what institutions should be advocated and what legislative changes should be opposed?

Still, after due attention has been paid to these indispensable matters, a little time might, perhaps, with advantage be devoted to the natural history of societies. Some guidance for political conduct would possibly be reached by asking, What is the normal course of social evolution, and how it will be affected by this or that policy? It may turn out that legislative action of no kind can be taken that is not either in harmony with, or at variance with, the processes of national growth and development as naturally going on; and that its desirableness is to be judged by this ultimate standard rather than by proximate standards. Without claiming too much, we may at any rate expect that, if there does exist an order among those structural and functional changes which societies pass through, knowledge of that order can scarcely fail to affect our judgments as to what is progressive, and what retrograde—what is desirable, what is practicable, what is Utopian.

To those who think such an inquiry worthy to be pursued, will be addressed the chapters that are to follow. There are sundry considerations important to be dwelt upon, before commencing Sociology. To a clear idea of the nature of the science have to be added clear ideas of the conditions to successful study of it. These will henceforth occupy us.

CLEVER FISHES.

By FRANCIS FRANCIS.

WHETHER we owe many of the matters we are about to glance at to fishes or no, it is certain that the fishes possessed them long before we did, and though man may be said to have invented them, yet in his savage state he must have taken more or less of hints from Nature, and have adopted the methods which Nature pointed out to him as the most effective in hunting or war (which were his principal occupations) whenever they could be adapted to his needs and appliances. However this may be, it is certainly singular that we should find so many existing similarities of a peculiar kind between the habits and attributes of men and fishes. For example, there is scarcely a sport we practise or a weapon of offence that we use which has not a

parallel among fishes. As to weapons—daggers, spears, swords, are all possessed by fish in a very high state of natural perfection, and even guns have a representative institution among fishes. A Shooting-Fish would no doubt be looked upon almost as a *lusus naturæ* by the average Englishman, who rarely includes ichthyology among his studies —a fact which is very much to be lamented, for we have large national interests bound up in that science; in fact, we owe a great deal more to fishes than any other nation, not even excluding the Dutch, some of whose cities were formerly figuratively described as built on fish-bones, and a professorial chair of Ichthyology at the universities would be by no means an unwise institution. It is not many years since, that a review which was published in an influential paper, dealing, among other things, with this special point, contemptuously dismissed the fact (as a traveller's tale) of there being such a thing as a shooting-fish. The ignorance among the general public on every thing relating to fish is at times perfectly surprising. I have seen small, worthless bass passed off as gray mullet; I have seen even nasty, gravid pond-roach hawked about as gray mullet; I have seen large bass actually sold for salmon at one of our fashionable watering-places. After this, if the Londoner constantly buys coarse, dry, tasteless bull-trout as fine Tay salmon, it is not to be wondered at.

The Eton boy hastening home for the holidays provides himself with a tin tube and a pocketful of peas. We beg the present Etonian's pardon; we should have said he used to do so formerly, when there were boys at Eton, and, backed by some skill as a marksman, therewith constituted himself an intolerable nuisance to every village and vehicle he passed on his road home. The Macoushee Indian makes a better use of his blow-tube; he puffs small arrows and hardened balls of clay through it with unerring aim, doing great execution among birds and other small game. Now, the Chætodon (*Chætodon rostratus*), which is more or less a native of the Eastern seas from Ceylon to Japan, rather perhaps resembles the Macoushee Indian than the Eton boy, though his gun, shooting-tube, or blow-pipe, or whatever it may be termed, is a natural one. His nose is really a kind of "beak," through which he has the power of propelling a small drop of water with some force and considerable accuracy of aim. Near the edge of the water is perhaps a spray of weed, a twig, or a tuft of grass; on it sits a fly, making its toilet in the watery mirror below. Rostratus advances cautiously under the fly; then he stealthily projects his tube from the water, takes a deadly aim, as though he were contesting for some piscatory Elcho shield, and pŏp goes the watery bullet.

"Poor insect, what a little day of sunny bliss is thine!"

Knocked over by the treacherous missile, drenched, stunned, half drowned, she drops from her perch into the waters below, to be sucked in by the Chætodon.

But if we have fishes who can shoot their game, we have also fishes who can fish for it; ay, and fish for it with rod and line, and bait, as deftly as ever angler coaxed gudgeons from the ooze of the New River or salmon from the flashing torrent of the Spey. Witness this clumsy-looking monster the Fishing-Frog (*Lophius piscatorius*). Frightful and hideous is he, according to our vulgar notions of loveliness, which the Lophius possibly might disagree with. The beast is sometimes five or six feet in length, with an enormous head in proportion to the rest of its body, and with huge sacs like bag-nets attached to its gill-covers, in which it stows its victims; and what a cavernous mouth! Surely a fish so repulsive, and with a capacity so vast and apparently omnivorous, would frighten from its neighborhood all other fish, and would, if its powers of locomotion were in accordance with its size, be the terror of the seas to fish smaller than itself; but Providence knoweth how to temper its gifts, and the Lophius is but an indifferent swimmer, and is too clumsy to support a predatory existence by the fleetness of its motions. How, then, is this huge capacity satisfied? Mark those two elongated tentacles which spring from the creature's nose, and how they taper away like veritable fishing-rods. To the end of them is attached, by a line or a slender filament, a small glittering morsel of membrane. This is the bait. The hooks are set in the mouth of the fisherman down below. But how is the animal to induce the fish to venture within reach of those formidable hooks? Now mark this perfect feat of angling. How does the Thames fisherman attract the gudgeons? They are shy; he must not let them see him, yet he must draw them to him, and he does it by stirring up the mud upon the bottom. "In that cloud of mud is food," say the gudgeons. Then the angler plies his rod and bait. Just so the Lophius proceeds, and he too stirs up the mud with his fins and tail. This serves not only to hide him, but to attract the fish. Then he plies *his* rod, and the glittering bait waves to and fro like a living insect glancing through the turbid water. The gudgeons, or rather gobies, rush toward it. "Beware! beware!" But when did gudgeon attend to warning yet? Suddenly, up rises the cavernous Nemesis from the cloud below, and "snap!" the gobies are entombed in the bag-net, thence to be transferred to the Lophius's stomach, when there are enough of them collected to form a satisfactory mouthful.

But we have still other sportsmen-fish; we have fish who hunt their prey singly, or in pairs, or even in packs, like hounds. The reader, possibly, has never witnessed a skäll in Scandinavia. It is a species of hunt in which a number of sportsmen take in a wide space of ground, where game exists, drawing a cordon around it, and narrowing their circle little by little, and driving the game together into a flock, when they shoot them down. There was some years ago a capital description of porpoises making a skäll upon sand-eels, written by the late Mr. James Lowe, sometime editor of the *Critic* and "Chronicler" of the

Field, who saw the sight while fishing near the Channel Islands with Peter le Nowry, the pilot. Having searched for this passage several times, without being able to find it, I am reluctantly compelled to quote from memory. They were fishing off Guernsey, when Mr. Lowe called Peter's attention to several porpoises, which seemed to be engaged in a water-frolic, swimming after one another in a circle. "That is no frolic, but very sober earnest for the sand-eels," said Peter. "Now," he continued, "I will show you a sight which I have only chanced to see two or three times in my life, and you therefore are very lucky to have the opportunity of seeing it at all. There is a great shoal of sand-eels yonder, and the porpoises are driving them into a mass; for, you see, the sand-eel is only a very small morsel for a porpoise, and to pick them up one by one would not suit Mr. Porpoise, who would get hungry again by the time he had done feeding on them singly; so they drive them into a thick crowd, in order that when they make a dash at them they may get a dozen or two at a mouthful. But, as we want some for bait, we will join in the hunt." And they edged down to the spot till they were within the circle. The porpoises, following one another pretty closely, were swimming round, now rising to the surface, now diving below, and gradually contracting the circle. The terrified sand-eels were driven closer and closer, and in their fear came to the surface all about the boat; and, just as two or three porpoises made a dash into the crowd, snapping right and left, the fishermen plunged their nets into the water, and brought them up quite full of these little fish. Of course the shoal soon broke up and dispersed, but the skill with which the skäll was conducted and the beauty of the sight were much dilated on by Mr. Lowe, and it must have been a very interesting one.

There are many fish which hunt their prey singly, as the pike and trout, and the way in which a large pike or trout will course and run down a smaller fish resembles nothing so much as a greyhound coursing a hare. Now the unhappy little fish turns from side to side in its efforts to escape, while its pursuer bends and turns to every motion, following close upon his track, and cutting him off exactly as a greyhound does a hare. Now he rushes among a shoal of his fellows, hoping to be lost sight of in the crowd and confusion; but the grim foe behind is not to baffled or deceived, and, singling him out and scattering the small fry, which fly in all directions, ruffling the surface of the water like a sudden squall of wind in their fright, follows up his victim with unerring instinct. In an agony of terror the poor little quarry springs again and again frantically from the water, only to fall at last exhausted into the gaping jaws of his ravenous foe, who, gripping his body crosswise in his mouth, sails steadily away to his lair, there to devour his prey at leisure. Other fish hunt their food like dogs or wolves in packs, as does the bonito chase the flying-fish, and one perhaps of the fiercest, most savage, and resolute of these is the Pirãi, of South America. So fierce and savage are these little pirates,

when their size and apparent capability are taken into consideration, that their feats of destructiveness are little short of the marvellous. Stand forth, then, "pirăi" of the Carib, "black, saw-bellied salmon" (*Serra salmo niger*) of Schomburgk; so called, doubtless, from the possession of the peculiar adipose fin, common only to the salmon tribe, though in no other respect does it resemble a salmon, there being positive structural differences between the species. Let us take the portrait of this fish. Doubtless the reader figures to himself a fish of "a lean and hungry look," a very Cassius of a fish, with the lantern-jaws of a pike. But, in fact, the pirăi is somewhat aldermanic and like a bream in figure, with a fighting-looking kind of nose, and a wondrously expressive eye—cold, cruel, and insatiable, and like to that of an old Jew bill-discounter when scrutinizing doubtful paper. There is 70 or 80 per cent. in that eye at the very least, and ruin to widows and orphans unnumbered if they come in its way. If it were a human eye, the owner would be bound sooner or later to figure at Execution Dock. The jaw is square, powerful, and locked into a very large head for the size of the fish; and that is a fat, plump head too, but radiated over with strong bone and gristle. The teeth—ah! they would condemn him anywhere, for here is a fish 16 inches long, with the teeth almost of a shark. Schomburgk speaks thus of its destructive power:

> This voracious fish is found plentifully in all the rivers in Guiana, and is dreaded by every other inhabitant or visitant of the river. Their jaws are so strong that they are able to bite off a man's finger or toe. They attack fish of ten times their own weight, and devour all but the head. They begin with the tail, and the fish, being left without the chief organ of motion, is devoured with ease, several going to participate of the meal. Indeed, there is scarcely any animal which it will not attack, man not excepted. Large alligators which have been wounded on the tail afford a fair chance of satisfying their hunger, *and even the toes of this formidable animal are not free from their attacks.* The feet of ducks and geese, where they are kept, are almost invariably cut off, and young ones devoured altogether. In these places *it is not safe to bathe*, or even to wash clothes, many cases having occurred of fingers and toes being cut off by them.

Schomburgk then relates astonishing instances of their voracity, in which the toes of the river Cavia are eaten off; a large sun-fish devoured alive; ducks and geese deprived of their feet, and walking on the stumps. Of course, the lines which are used to capture them have to be armed with metal, to prevent their being cut through. Their voracity is marvellous, and any bait will attract them the instant it is thrown into the water. Precaution is necessary, however, when the fish is lifted out of the water, or it will inflict serious wounds in its struggles. The fisherman, therefore, has a small bludgeon ready, with which he breaks their skulls as soon as they are caught.

Thus there are fish which shoot their prey, which fish for it, which course it and hunt it, in various ways. There are others which employ

other ushes to hunt it up for them, as we use pointers and setters, such as the little Pilot-fish, which leads the huge shark to his prey; though this has been disputed, because the pilot-fish has been known to follow and play about a vessel just as it does usually about the body of a shark. The probability is, that the pilot-fish is a species of parasite or diner-out, who will make particular friends with any big person who will feed him, and no doubt would find food in the refuse cast from the vessel, even as he would from the fragments torn off by the shark when feeding on any large body. Doubtless, too, there is a certain amount of protection obtained from consorting with monsters against other predacious fish. The fact of the pilot-fish conducting the shark to his prey has been disputed, but veritable instances related by eye-witnesses leave no doubt that at times it does fulfil this office for the shark. Nor is there any thing singular in the fact. The pilot-fish is on the lookout for his own dinner probably, but will not venture on it until his protector has helped himself. We have numerous instances of this both in human and beast life.

In weapons of offence, besides the shooting apparatus already mentioned, fish have, first, the sword. This is represented by the blade of the sword-fish (*Xiphias gladius*). This fish possesses a tremendously powerful weapon, backed as it is by the great weight and impetus which it can bring to bear upon its thrusts. Many instances have been known in which the bottoms of ships have been pierced through by the sword of the Xiphias. Ships sailing quietly along have received a shock as if they had touched a rock, and, when they have been examined after the voyage, the broken blade of the fish has been found sticking in the ship's side. In the United Service Museum there is, or was formerly, a specimen of the sword-fish's handiwork in this respect. A portion of the weapon is shown sticking into the timbers of a ship, having pierced the sheathing and planking, and buried itself deeply in the stout oak knee-timber of the vessel. Xiphias would, however, be terribly bothered with the change in naval architecture; and we are inclined to wonder what he would make of an iron-clad. Perhaps a little rough experience in this direction may make him more chary of indulging naughty tempers, and he may be taught *qua* Dr. Watts that, like little children, he "should not let his angry passions rise." If so, the cause of humanity will be strongly pleaded by the iron-clads, and the poor, clumsy, harmless whale will be the gainer. The xiphias frequently weighs 500 or 600 pounds. The rapidity with which it can cut through the water is very great. It is a great enemy to the whale, and it is generally surmised that it mistakes a ship sailing through the water for a whale, and dashes at it with indiscriminating rage, often breaking and losing its sword by its blind fury. Persons bathing have not always been entirely safe from this fish, but have been stabbed to death by the xiphias. One instance of this occurred in the Bristol Channel, near the mouth of the Severn, in which

a small fish of some 70 or 80 pounds weight was the malefactor. They abound in the Mediterranean, and a hunt after, with the harpooning and slaying of the xiphias, is usually a work of time and much excitement. Akin to the sword-fish in their offensive capabilities are the saw-fishes, though their weapons resemble rather such as are used by certain savage tribes than civilized saws. Nor does the word "saw" correctly describe them. They are terrible weapons, however, and the Indians who edge their spears with shark's teeth almost reproduce artificially the weapon of the saw-fish. The largest of them, *Pristis antiquorum*, is commonly found to grow to the length of 15 or 16 feet. The elongated snout is set upon either side with sharp spikes, thickly dispersed, and somewhat resembling the teeth of the shark. It forms a most fearful weapon, as the poor whale has good reason to know, to whom it is also a deadly enemy. There are several members of the saw-fish tribe; one of the most peculiar is the *Pristis cirratus*, or cirrated saw-fish, of New South Wales. In the saw of this fish the teeth are irregular, one long and three short ones being placed alternately.

The weapon of the Narwhal—which, by-the-by, is not strictly a fish, but a member of the Cetacea, found chiefly in the Arctic seas—is the most perfect specimen of a very complete and efficient spear, being composed of the hardest ivory, and tapering gradually to a point. But, what the special purpose of this spear is, is not known; whether it is used as a means of attack upon its enemies, or to secure its prey, or whether it is a mere implement for digging a passage through opposing ice-floes, as is often supposed, we can but conjecture. It is a very singular fact that the spear of the narwhal is always situated on one side of the nose, chiefly the left; it does not project from the middle of the head; it is no long snout or horn,[1] but an elongated tooth or tusk. The narwhal, when young, has the germs of but three teeth. Sometimes two of these become developed and grow out spiked tusks, pointing in divergent directions; oftener, however, but one is the mature result. Whatever the use of this formidable spear may be, we know that it is very excellent and valuable ivory; but, for any minute information as to the natural history of the animal itself, we should have to rely chiefly upon the knowledge of the Kamtchatkans, which amounts to little more than that it is good eating, produces much oil, and is possessed of a valuable tooth.

Of daggers various we have many specimens, more particularly among the family of the Raiidæ;[2] and fearful weapons they are, some of them being serrated or barbed, and capable of inflicting terrible lacerated wounds. In most of these fish the dagger, or spine, is situated on and some way down the elongated tail; and, as the animal

[1] These spears were brought home formerly and imposed upon the credulous as the horn of the unicorn.

[2] There are three species of rays in this country which have these weapons—the Sting Ray, the Eagle Ray, and the Horned Ray.

has great muscular power in the tail, and is able to whirl it about in any direction it may desire, it not unfrequently deals forth most savage retribution to its captors. It knows full well, too, how to direct its aim, and it is told of some of the members of this family that, if a hand, or even a finger, be laid upon the fish, it can, by a single turn of the tail, transfix with its spine the offending member. So dangerous are the consequences of these wounds, that it is customary (and in France and Italy it is made compulsory by law on the fishermen) to cut off the tails above the spines of the fish thus armed before they are brought to market; and in this way almost the only specimen of the Eagle Ray (*Myliobatis aquila*) ever captured alive in this country[1] was mutilated; so that the specimen was useless. The Picked Dogfish is also provided with two short, sharp spines—one on each dorsal fin. Many other fish are furnished with spines, either upon the fins or as horns, or in sharp projections from the gill-covers. The spines of the Greater and Lesser Weaver inflict most painful wounds, and cause such agony that it is commonly reported they are in some way venomous. This has been denied, and demonstrated to be impossible; yet it seems difficult to account for the following facts upon any other hypothesis. Sir W. Jardine, in speaking of the greater weaver, says:

> It is much dreaded by the fishermen on account of its sharp spines, which are usually considered as venomous, but without any sufficient reason, as they are quite devoid of all poisonous secretion. Mr. Couch states that he has known three men wounded successively in the hand by the same fish, and *the consequences have in a few minutes been felt as high as the shoulder.*

Again, in treating of the lesser weaver, "If trodden on by bathers, as frequently happens, it inflicts," says Dr. Parnell, "a severe and painful wound, causing the part to swell and *almost immediately to assume* a dark-brown appearance, which remains for five or six hours."

In the teeth of the confident assertion of great authorities it would be rash to say that any poisonous secretion exists. But, if the above facts be quoted as proofs or instances of the absence of venom, they would appear to be singularly infelicitous ones.

Perhaps one of the most formidable weapons possessed by any fish is the natural and terrible pair of shears formed by the jaws of the Shark. The only parallel weapon of offence that can be cited as used by man would, perhaps, be the spiked portcullis, but the future *may*

[1] This fish was captured at Ramsgate some years ago and sent to me; it was 18 inches long, exclusive of the tail, which was missing, and about 2½ feet broad. Previous to this the tail of one was examined by Pennant, and a small one was found dead off Berwick by Dr. Johnson, but no living specimen had been captured. Since this was penned, however, but a few months ago, another was caught and attracted a good deal of notice. This fish was taken off the Devonshire coast, and was about the same size as, or a trifle larger than, mine. It was preserved in the Exeter Museum, where it now is. Mr. Buckland very kindly sent me an excellent photograph of the fish. The colors appear to have been most brilliant.

present us with steam shears with blades ten feet long, and intended to receive cavalry—who knows? There is no telling where the ingenuity of modern inventors in the destructive line may lead us. But there are not many instruments so efficient for their purpose as the tooth of a shark. It is difficult to handle one freely without cutting one's fingers; and when we consider the tremendous leverage of a shark's jaws employed against each other like scissors, armed with rows of lancets, it is evident that nothing in the shape of flesh, gristle, or bone, could withstand them. Their capacity, too, is equal to their powers, for a pair of jaws taken from a shark of not more than nine feet long has been known to be passed down over the shoulders and body of a man six feet high without inconvenience. It was thought to be an act of very unusual strength and dexterity on the part of the Emperor Commodus to cut a man in two at one blow, but the jaws of the white shark find no difficulty whatever in executing that feat. The vast number of teeth contained within the shark's jaw has been accounted for by some writers on the hypothesis that they are erected when the shark seizes its prey, at all other times lying flat on their sides. It is now, however, more generally admitted that the shark only employs the outer row of teeth, and that the inner ones are a provision of Nature against an accident which is, and must be, a very common one when the implements are considered, and the force with which they are employed—viz., the breaking of a tooth. In this case the corresponding tooth on the inside becomes erect, and is by degrees pushed forward into the place of the broken one—a wondrous and very necessary provision to keep so delicate and powerful an apparatus as the shark's jaw always in order. The voracity of the shark forms an endless resource for the writers on the marvellous whose bent lies toward natural history. Whole ships' crews have been devoured by sharks ere now, while their omnivorousness is extraordinary. This is well exemplified by the observation once made to me by an old tar, who was dilating on the variety of objects he had found at one time or another inside the bellies of sundry sharks. "Lord love ye, sir," quo' Ben, "there bain't nothin' as you mightn't expec' to find in the insides o' a shirk, from a street pianny to a milestone!"[1]

Continuing the description of the variety of weapons exemplified in fishes, we have a rival of that terrible scourge the knout in the tail of the Thresher, or Fox-shark (*Alopias vulpes*). The upper lobe is tremendously elongated, being nearly as long as the body of the fish, and amazingly muscular. It is curved like the blade of a scythe in shape, and the blows which it can and does inflict with this living flail can be

[1] Witness the story of the Magpie schooner, very well told in the "Shipwreck" series of the "Percy Anecdotes." This vessel was capsized in a squall, and most of the crew took refuge in a boat, which was upset by overcrowding. They were surrounded by sharks at the time, and every man, save two, who managed to right the boat and escape, was devoured by the sharks.

heard at a great distance; a herd of dolphins are scattered as though they were mere sprats, by one stroke of the thresher's tail, and stories of the combats between the whale on the one side and a combination of threshers and sword-fish on the other are too common to need more than a reference here. The form of battle usually consists in the sword-fish stabbing the whale from beneath, and so driving him up to the surface, when the fox-sharks spring upon him, and with resonant blows from their fearful knouts drive him below again upon the weapons of their allies.

The lasso is a weapon of some efficacy among various people; a form of lasso was even used by the Hungarians, and with great effect, in the War of Independence. It consisted of a kind of long-lashed whip, with a bullet slung at the end of the lash. And we have a sort of living lasso in the foot of the Cephalopod. The cephalopods are the polypes of Aristotle, and belong to the mollusks. They are of the first order of invertebrate, or spineless animals. *Mollusca cephalopoda* is the style and titles of the family Cephalopoda, in English meaning "foot-headed"—that is, its organs of locomotion, or the greater part of them, are attached to its head, whence they radiate for the most part in long, tough, and pliant tentacles or arms, of great muscular powers. On these tentacles are placed rows of suckers of very singular construction, which singly or simultaneously adhere with great tenacity to any object they come in contact with. The arms are extended in all directions when seeking prey. In the centre of them, in the middle of the stomach as it were, is the mouth of the creature, which is fully as curious as the rest of its anatomy, and consists of a large and strong-hooked beak, similar to a hawk's or parrot's. A fish or other creature comes within reach, and is instantly lassoed by one of the tentacles, the others winding around it also, to secure it in their folds. It is compressed tightly and drawn down to the beak, which rends and devours it at leisure, escape from these terrible folds being almost impossible.

The arms are also the means of propulsion, and are used as oars, by the aid of which the Octopus manages to progress through the water with considerable rapidity. Mr. Wood, in his popular natural history, treats on this point as follows: "All the Squids are very active, and some species, called 'flying squids' by sailors, and *ommastrephes* by naturalists, are able to dash out of the sea and to dart to considerable distances;" and he quotes Mr. Beale to show that they sometimes manage to propel themselves through the air for a distance of 80 or 100 yards, the action being likened to a something which might be achieved by a live corkscrew with eight prongs. In the account given in Bennett's "Whaling Voyage" they are often spoken of as leaping on board the ship, and even clear over it into the water on the other side. Nature has also furnished the cephalopod with another curious weapon of offence, or defence rather, in the shape of a bag of black

fluid, or sepia, commonly termed by fishermen the ink-bag; and what a dreadful weapon of offence or defence ink may be, in many cases, there are few of us unaware. The cuttle when closely pursued sends out a cloud of it to hide him from view, and escapes under cover of it.

Some of the cephalopods possess extraordinary powers of muscular contraction, as the common squid, for example, which is spread out at one moment in a body and volume larger round than a large man's fist, and the next moment will contract itself so that it can easily pass through the cork-hole in a boat or the neck of a wine-bottle. Great sensational attraction has been directed to the octopus by the tremendous description of the combat in Victor Hugo's "Toilers of the Sea." No doubt a large octopus, such as are found in the Pacific and elsewhere, and which sometimes have arms of eight or nine feet in length, could drown a man with the greatest ease, if he had no weapon, and were caught by one under water. From remote ages the deeds of the polypus have been chronicled by poets and writers of strong imaginative powers; and thus we have, probably, the partially fabulous story of the Lernæan hydra, which, if it ever existed at all, had its origin no doubt in the impossible deeds of some improbable octopus. Then there is the story of the king's daughter and the noble diver, who dived for a gold cup and the love of his princess, but profited by neither, since he never came up again, being supposed to have been lassoed by some monster octopus at the bottom of the whirlpool, and many other well-known stories. The beast forms a very great attraction at the Crystal Palace aquarium, where the ladies, of course, insist on calling him "the Devil-Fish" (but that distinguished title belongs to another fish); and where he is poked up daily for their inspection, it being one of his diabolical tendencies to dwell "under ebon shades and low-browed rocks." What a life for a poor devil who wants nothing but solitude and retirement, to BE a show-devil and at the beck and call of the ladies!

Among other offensive powers commanded by fish and men alike is the very remarkable one of electricity; it is slightly used in warlike as well as useful purposes. But the possible uses to which we may put electricity ourselves hereafter as an offensive weapon we cannot at present even guess at. It is a powerful agent to several kinds of fish, and yet ichthyologists are greatly at fault to settle the exact purpose for which it is given to them—whether it be for the purpose of killing the animals they prey on, or of facilitating their capture, or whether it be intended to render them more easy of digestion.

Mr. Couch, in speaking of the properties of electricity and the digestive capability of the Torpedo, has the following: "One well-known effect of the electric shock is to deprive animals killed by it of their organic irritability, and consequently to render them more easily disposed to pass into a state of decomposition, in which condition the digestive powers more speedily and effectively act upon them. If any

creature more than others might seem to require such preparation of its food, it is the cramp ray, the whole canal of whose intestine is not more than half as long as the stomach." This is certainly very curious, and, if it should be found that the same deficiency in point of digestive accommodation exists in the gymnotus and the other fishes of electric powers, the hypothesis would be converted almost into a certainty. In hunting up authorities to verify this curious fact, we find, in the article on the gymnotus in *Chambers's Encyclopædia*, that "all the gymnotidæ are remarkable for the position of the *anus*, which is so very far forward as, *in the electrical eel, to be before the gill-openings*," which would certainly seem to confirm Mr. Couch's supposition.

Of the tremendous powers which can be given off in one shock, it may be stated that Faraday, having made experiments with the specimen which was shown several years ago at the Adelaide Gallery, estimated that an average shock emitted as great a force as the highest force of a Leyden battery of fifteen jars, exposing 3,500 inches of coated surface.

There are five different fish endued with electrical powers. Of the torpedo there are two species—the old and new British torpedo; one of the *Gymnotus electricus*, or electric eel, as it is called; and two of the *Malapterurus*—viz., *M. electricus* of the Nile, called Raash, or thunder-fish, by the Arabs, and the *Malapterurus Beninensis*—the smallest of the electrical fishes, found in the Old Calabar River, which falls into the Bight of Benin, on the coast of Africa. The latter fish is a comparatively recent discovery, having been known to us only some fifteen or sixteen years. We have no very good account of either of these latter fish. A specimen of the last was sent to me three or four years ago. It is a curious little fish, about five or six inches in length, and very much resembles the *Siluridæ* in general appearance, about the head especially. It has long barbules, three on each side of the mouth, and has a very bloated, puffy appearance, caused, it is to be presumed, by the electric apparatus which is deposited between the skin and the frame of the fish. In the torpedo the electric battery is placed in two holes, one on either side of the eyes. Here a number of prismatic cells are arranged in the fashion of a honey-comb, the number being regulated by the age of the fish. These represent the jars in the battery, and they are capable of giving out a terrible shock, as many an incautious fisherman has experienced to his cost. We may trust also that the torpedoes with which our coasts and harbors are likely to be thronged will be capable of giving off even a severer shock; and though gunpowder and gun-cotton will be the shocking agents in these cases, yet electricity will play no unimportant part in their process. Formerly quacks galvanized their patients by the application of the natural torpedo, applying it to the joints and limbs for gout, rheumatism, etc. That the electricity is true electricity has been proved by a host of experiments. The electrometer has shown it,

and needles have been magnetized just as if a battery had been employed.

There are many other points of similarity which might be enlarged upon; but, if one were to attempt to set down all the strange and various considerations which come under cognizance in this subject, they would soon swell the matter much beyond the limits of a magazine article.—*Fraser's Magazine.*

MOTIONS OF THE STARS.

AT the last meeting of the Royal Astronomical Society, Dr. Huggins, the eminent spectroscopist, made an extraordinary statement respecting the motions taking place among the stars. The results he announces are so wonderful that it will be well briefly to explain how they have been obtained, as well as their relation to what had formerly been known upon the subject.

Our readers are doubtless aware that the stars are not really fixed, but are known to be travelling swiftly through space. To ordinary observation the stars seem unmoving; nor indeed can the astronomer recognize any signs of motion save by prolonged observation. But, if the exact place of a star be carefully determined at any time, and again many years later, a measurable displacement can be recognized; year after year, and century after century, the motion thus determined proceeds, until at length the star may be removed by a considerable arc (or what is so regarded by astronomers accustomed to deal with the minutest displacements) from the position it had formerly occupied.

But, in general, these movements afford no means of estimating the real rate at which the stars are travelling through space. In the first place, a star might be moving with enormous rapidity toward or from the earth, and yet seem to be quite fixed on the star-vault—just as the light of a rapidly approaching or receding train seems to occupy an unchanging position if the train's course is at the moment in the direction of the line of sight. It is only what may be called the thwart-motion of the star that the astronomer can recognize by noting stellar displacements. But even this motion he cannot estimate—in miles per second, say—unless he knows how far off the sun is; and astronomers know in truth very little about stellar distances.

Now, it seems, at first sight, altogether hopeless to attempt to measure the rate at which a star is approaching or receding. No change of brightness could be looked for, nor indeed could any observed change be trusted as an evidence of changed distance, since stars are liable to real changes of brilliancy, much as our own sun is liable to be more or less spot-marked. But the distances of the

stars are so enormous that no conceivable rate of approach or recession could affect their brilliancy discernibly. Only the most rapid thwart-motions yet recognized would carry a star over a space equal to the moon's seeming diameter in 500 years, so that a corresponding motion of recess or approach would only change a star's distance to about the same relative extent, and it is obvious that such a change could not make a star, even in that long period, change appreciably in brightness.

It will seem, then, utterly incredible that astronomers have learned not merely whether certain stars are receding or approaching, but have actually been enabled to determine respecting this kind of motion what they cannot determine respecting the more obvious thwart-motion, viz., the rate at which the motion takes place.

This is rendered possible by what is known of the nature of light. Light travels through space in waves, not as a direct emanation. Now, let us compare a star's action in emitting such waves with some known kind of wave-action, and we shall at once recognize the effects of very rapid motion on the star's part. Conceive a fixed paddle-wheel turning at a uniform rate in water, and that every blade as it reaches the water raises one wave, that wave being transmitted in a given direction. Then there would be a succession of waves separated from each other by a constant distance. But, suppose the paddle-wheel itself to be carried in the given direction. It is clear that, after one blade has raised its wave, the next blade, descending in the same time as before, will reach the water closer to the preceding wave than if the paddle-wheel had been at rest; for the moving wheel will have *carried* the blade closer, so that now a succession of waves will result as before, but they will have their crests closer together. And obviously, if the wheel were carried in the contrary direction, the wave-crests would be farther apart than if the wheel had been at rest.

Thus, reverting to the stars, we infer that if a star is approaching, the light which comes to us from it will have its waves closer together than if the star were at rest, and *vice versa*. Now, the distance between the wave-crests of light signifies a difference of color, the longer waves producing red and orange light; waves of medium length, yellow and green light; and the shorter waves producing blue, indigo, and violet light. So that, if a star were shining with pure red light, it might by approaching very rapidly be caused to appear yellow, or even blue or indigo, according to the rate of approach; while, if a star were shining with pure indigo light, it might by receding very rapidly be caused to appear green or yellow, or even orange or red.

But stars do not shine with pure-colored light, but with a mixture of all the colors of the rainbow; so that the attempt to estimate a star's rate of approach or recession by its color would fail, even though we knew the star's real color, and even though stars moved fast enough to produce color-changes. The spectroscopist has, however, a much

more delicate means of dealing with the matter. The rainbow-tinted streak forming a star's spectrum is crossed by known dark lines; and these serve as veritable mile-marks for the spectroscopist. If one of these lines in the spectrum of any star is seen to be shifted toward the red end, the observer knows that the star is receding, and that swiftly; if the shift is toward the violet end, he knows that the star is swiftly approaching

Now, Dr. Huggins had been able nearly four years ago to apply this method to the case of the bright star Sirius, though his instrumental means were not then sufficient to render him quite certain as to the result. Still he was able to announce with some degree of confidence that Sirius is receding at a rate exceeding 20 miles per second. In order that he might extend the method to other stars, the Royal Society placed at his disposal a fine telescope, 15 inches in aperture, and specially adapted to gather as much light as possible with that aperture. Suitable spectroscopic appliances were also provided for the delicate work Dr. Huggins was to undertake. It was but last winter that the instrument was ready for work; but already Dr. Huggins has obtained the most wonderful news from the stars with its aid. He finds that many of the stars are travelling far more swiftly than had been supposed. Arcturus, for example, is travelling toward us at the rate of some 50 miles per second, and, as his thwart-motion is fully as great (for this star's distance has been estimated), the actual velocity with which he is speeding through space cannot be less than 70 miles per second. Other stars are moving with corresponding velocities.

But, amid the motions thus detected, Dr. Huggins has traced the signs of law. First he can trace a tendency among the stars in one part of the heavens to approach the earth, while the stars in the opposite part of the heavens are receding from us; and the stars which are approaching lie on that side of the heavens toward which Herschel long since taught us that the sun is travelling. But there are stars not obeying this simple law; and among these Dr. Huggins recognizes instances of that community of motion to which a modern student of the stars has given the name of star-drift. It happens, indeed, that one of the most remarkable of these instances relates to five well-known stars, which had been particularly pointed to as forming a drifting set. It had been asserted more than two years ago that certain five stars of the Plough or Charles's Wain—the stars known to astronomers as Beta, Gamma, Delta, Epsilon, and Zeta, of the Great Bear—are drifting bodily through space. The announcement seemed to many very daring, yet its author (trusting in the mathematical analysis of the evidence) expressed unquestioning confidence; he asserted, moreover, that whenever Dr. Huggins applied the new method of research, he would find that those five stars are either all approaching or all receding, and at the same rate, from the earth. The result has justified his confidence as well in his theory as in Dr. Huggins's mastery of the new method. Those

five stars are found to be all receding from the earth at the rate of about 30 miles per second.

This result at once illustrates the interesting nature of Dr. Huggins's discoveries, and affords promise of future relevations even more interesting. The theories hitherto accepted respecting the constitution of the stellar universe have been tried against the views recently propounded, with a result decidedly in favor of the latter. We may feel assured that the matter will not rest here. A simple and decisive piece of evidence, such as that we have described, will invite many to examine afresh the theories respecting the stellar heavens which have so long been received unquestioningly. The theory of star-drift is associated with others equally novel, and which admit equally well of being put to test. We venture to predict that, before many years have passed, there will be recognized in the star-depths a variety of constitution and a complexity of arrangement startlingly contrasted with the general uniformity of structure recognized in the teachings at present accepted.—*Spectator.*

THE UNCONSCIOUS ACTION OF THE BRAIN.

By WM. B. CARPENTER, M. D., LL. D., F. R. S.

MANY of you, I doubt not, will remember that I had the pleasure of addressing you in this hall some months ago, with reference to researches which I had a share in carrying on into the Depths of the Ocean, when I endeavored to give you some insight into the conditions of the sea-bottom as regards temperature, pressure, animal life, and the deposits now in process of formation upon it.

Now, I am going this evening to carry you into quite a different field of inquiry—an inquiry which I venture to think I have had some share in myself promoting, into what goes on in the Depths of our own Minds. And I think I shall be able to show you that some practical results of great value in our own mental culture, as training and as discipline, may be deduced from this inquiry. I shall begin with an anecdote that was related to me after a lecture which I gave upon this subject about five years ago, at the Royal Institution, in London. As I was coming out from the lecture-room, a gentleman stopped me and said, "A circumstance occurred recently in the north of England, which I think will interest you, from its affording an exact illustration of the doctrine which you have been setting forth to-night." The illustration was so apposite, and leads us so directly into the very heart of the inquiry, that I shall make it, as it were, the text for the commencement of this evening's lecture. The manager of a bank in a certain

[1] A lecture, delivered in the Hulme Town Hall, Manchester.

large town in Yorkshire could not find a key which gave access to all the safes and desks in the bank. This key was a duplicate key, and ought to have been found in a place accessible only to himself and to the assistant-manager. The assistant-manager was absent on a holiday in Wales, and the manager's first impression was, that the key had probably been taken away by this assistant in mistake. He wrote to him, and learned to his own great surprise and distress that he had not got the key, and knew nothing of it. Of course, the idea that the key, which gave access to every valuable in the bank, was in the hands of any wrong person, having been taken with a felonious intention, was to him most distressing. He made search everywhere, thought of every place in which the key might possibly be, and could not find it. The assistant-manager was recalled, both he and every person in the bank were questioned, but no one could give any idea of where the key could be. Of course, although no robbery had taken place up this point, there was the apprehension that a robbery might be committed after the storm, so to speak, had blown over, when a better opportunity would be afforded by the absence of the same degree of watchfulness. A first-class detective was then brought down from London, and this man had every opportunity given him of making inquiries; every person in the bank was brought up before him; he applied all those means of investigation which a very able man of this class knows how to employ; and at last he came to the manager and said: "I am perfectly satisfied that no one in the bank knows any thing about this lost key. You may rest assured that you have put it somewhere yourself, and you have been worrying yourself so much about it that you have forgotten where you put it away. As long as you worry yourself in this manner, you will not remember it; but go to bed to-night with the assurance that it will be all right; get a good night's sleep; and in the morning I think it is very likely you will remember where you have put the key." This turned out exactly as it was predicted. The key was found the next morning in some extraordinarily secure place which the manager had not previously thought of, but in which he then felt sure he must have put it himself.

Now, then, ladies and gentlemen, this you may say is merely a remarkable case of that which we all of us are continually experiencing; and so I say it is. Who is there among you who has not had occasion some time or other to try to recall something to his (or her) mind which he has not been able to bring to it? He has seen some one in the street, for instance, whose face he recognizes, and says, "I ought to know that person;" and thinks who it can be, going over (it may be) his whole list of friends and acquaintances in his mind, without being able to recall who it is; and yet, some hours afterward, or it may be the next day, it flashes into his mind who this unknown person is. Or you may want to remember some particular and recent event; or it may be, as I have heard classical scholars say, to recall the source of a

classical quotation. They "cudgel their brains," to use a common expression, and are unsuccessful; they give their minds to something entirely different; and some hours afterward, when their thoughts are far away from the subject on which they had been concentrating them with the idea of recovering this lost clew, the thing flashes into the mind. Now, this is so common an occurrence, that we pass it by without taking particular note of it; and yet I believe that the inquiry into the real nature of this occurrence may lead us to understand something of the inner mechanism of our own minds which we shall find to be very useful to us.

There is another point, however, arising out of the story which I have just told you, upon which again I would fix your attention: Why and how did the detective arrive at this assurance from the result of his inquiries? It was a matter of judgment based upon long practice and experience, which had given him that kind of insight into the characters, dispositions, and nature of the persons who were brought before him, which only those who have got this faculty as an original gift, or have acquired it by very long experience, can possess with any thing like that degree of assurance which he was able to entertain. I believe that this particular power of the detective is, so to speak, an exaltation in a particular direction of what we call "common-sense." We are continually bringing to the test of this common-sense a great number of matters which we cannot decide by reason; a number of matters as to which, if we were to begin to argue, there may be so much to be said on both sides, that we may be unable to come to a conclusion. And yet, with regard to a great many of these subjects—some of which I shall have to discuss in my next lecture—we consider that common-sense gives us a much better result than any elaborate discussion. Now, I will give you an illustration of this which you will all readily comprehend: Why do we believe in an external world? Why do I believe that I have at present before me many hundreds of intelligent auditors, looking up and listening to every word that I say? Why do you believe that you are hearing me lecture? You will say at once that your common-sense tells you. I see you; you see and hear me; and I know that I am addressing you. But if once this subject is logically discussed, if once we go into it on the basis of a pure reasoning process, it is found really impossible to construct such a proof as shall satisfy every logician. As far as my knowledge extends, every logician is able to pick a hole in every other logician's proof. Now, here we have, then, a case obvious to you all, in which common-sense decides for us without any doubt or hesitation at all. And I venture to use an expression upon this point which has been quoted with approval by one of the best logicians and metaphysicians of our time, Archbishop Manning, who cited the words that I have used, and entirely concurred in them, namely, that "in regard to the existence of the external world the common-sense decision of mankind

is practically worth more than all the arguments of all the logicians who have discussed the basis of our belief in it." And so, again, with regard to another point which more nearly touches our subject to-night—the fact that we have a Will which dominates over our actions; that we are not merely the slaves of automatic impulse which some philosophers would make us—"the decision of mankind" (as Archbishop Manning, applying my words, has most truly said), "derived from consciousness of the existence of our living self or personality, whereby we think, will, or act, is practically worth more than all the arguments of all the logicians who have discussed the basis of our belief in it."

Now, then, my two points are these: What is the nature of this process which evolves, as it were, this result unconsciously to ourselves, when we have been either asleep, as in the case of the banker, or, as in the other familiar case I have cited, when we have been giving our minds to some other train of thought in the interval? What is it that brings up spontaneously to our consciousness a fact which we endeavored to recall with all the force of our will, and yet could not succeed?

And then again: What is the nature of this common-sense, to which we defer so implicitly and immediately in all the ordinary judgments of our lives?

Now, in order that we may have a really scientific conception of the doctrine I would present to you, I must take you into an inquiry with regard to some of the simpler functions of our bodies, from which we shall rise to the simpler actions of our minds. You all know that the Brain, using the term in its general sense, is the organ of our Mind. That every one will admit. We shall not go into any of the disputed questions as to the relations of Mind and Matter; for the fact is, that these are now coming to take quite a new aspect, from Physical philosophers dwelling so much more upon Force than they do upon Matter, and on the relations of Mind and Force, which every one is coming to recognize. Thus, when we speak of nerve-force and mind as having a most intimate relation, no one is found to dispute it; whereas, when we talk about Brain and Mind having this intimate relation, and Mind being the function of the brain, there are a great many who will rise up against us and charge us with materialism, and atheism, and all the other deadly sins of that kind. I merely speak of the relation of the brain to the mind, as the instrument through which the mind operates and expresses itself. We all know that it is in virtue of the impressions carried to the brain, through the nerves proceeding from the different sensory organs in various parts of the body, that we become conscious of what is taking place around us. And, again, that it is through the nerves proceeding from the brain that we are able to execute those movements which the Will prompts and dictates, or which arise from the play of the Emotions. But I have first to speak of a set of lower centres, those which

the Will can to a certain extent control, but which are not in such immediate relation to it as is the brain. You all know that there passes down our backbone a cord which is commonly called the "Spinal Marrow." Now, this spinal marrow gives off a pair of nerves at every division of the backbone; and these nerves are double in function—one set of fibres conveying impressions from the surface to the spinal cord, the other motor impulses from the spinal cord to the muscles. Now, it used to be considered that this Spinal Cord (I use the term spinal cord, which is the same as spinal marrow, because it is just as intelligible and more correct) was a mere bundle of nerves proceeding from the brain; but we have long known that this is not the case, that the spinal cord is really a nervous centre in itself, and that if there were no brain at all the spinal cord would still do a great deal. For example, there have been infants born without a brain, yet these infants have breathed, have cried, have sucked, and this in virtue of the separate existence and the independent action of this spinal cord. Let us analyze one or two of these actions. We will take the act of Sucking as the best example, because experiments have been made upon young puppies, by taking out the brain, and then trying whether they would suck; and it was found that putting between the lips the finger moistened with milk or with sugar and water, produced a distinct act of suction, just as when an infant is nursed. Now, how is this? It is what we call a "reflex action." I shall have a good deal to say of reflex action higher up in the nervous system, and therefore I must explain precisely what we mean by that term. It is just this: There is a certain part of the spinal cord, at the top of the neck, which is what we call a ganglion, that is, a centre of nervous power: in fact, the whole of the spinal cord is a series of such ganglia; but this ganglion at the top of the neck is the one which is the centre of the actions which are concerned in the act of sucking. Now, this act of sucking is rather a complicated one, it involves the action of a great many muscles put into conjoint and harmonious contraction. We will say, then, that here is a nervous centre. [Dr. Carpenter made a sketch upon the black-board.] These are nerves coming to it, branches from the lips; and these another set going to the muscles concerned in the movement of sucking from it. Thus, by the conveyance to the ganglionic centre of the impression made on the lips, a complicated action is excited, requiring the combination of a number of separate muscular movements. We will take another example—the act of Coughing. You feel a tickling in your throat, and you feel an impulse to cough which you cannot resist; and this may take place not only when you are awake and feel the impulse, but when you are asleep and do not feel it. You will often find persons coughing violently in sleep, without waking or showing any sign of consciousness. Here, again, the stimulus, as we call it, produced by some irritation in the throat, gives rise to a change in the nerves going toward the ganglionic centre, which produces the excitement of an action in that

centre that issues the mandate, so to speak, through the motor nerves to the muscles concerned in coughing, which actions have to be united in a very remarkable manner, which I cannot stop to analyze; but the whole action of coughing has for its effect the driving out a violent blast of air, which tends to expel the offending substance. Thus, when any thing "goes the wrong way," as we term it—a crumb of bread, or a drop of water finding its way into the windpipe, then this sudden and violent blast of air tends to expel it.

Now, these are examples of what we call "reflex action;" and this is the character of most of the movements that are immediately concerned with the maintenance of the vital functions. I might analyze other cases. The act of breathing is a purely reflex action, and goes on when we are perfectly unconscious of exerting any effort, and when our attention is entirely given up to some act or thought; and even when asleep the act of breathing goes on with perfect regularity, and, if it were to stop, of course the stoppage would have a fatal effect upon our lives. But most of these reflex actions are to a certain degree placed under the control of our Will. If it were not for this controlling power of will, I could not be addressing you at this moment. I am able so to regulate my breath as to make it subservient to the act of speech; but that is the case only to a certain point. I could not go on through a long sentence without taking my breath. I am obliged to renew the breath frequently, in order to be able to sustain the circulation and other functions of life. But still I have that degree of control over the act of respiration, that I can regulate this drawing in and expulsion of the breath for the purposes of speech. This may give you an idea of the way in which Mental operations may be independent of the Will, and yet be under its direction. To this we shall presently come.

Now, those reflex actions of the spinal cord, which are immediately and essentially necessary to the maintenance of our lives, take place from the commencement without any training, without any education; they are what we call "instinctive actions;" the tendency to them is part of our nature; it is born with us. But, on the other hand, there are a great many actions which we learn, to which we are trained in the process of bodily education, so to speak, and which, when we have learned them, come to be performed as frequently, regularly, methodically, and unconsciously, as those of which I have spoken. This is the case particularly with the act of walking. You all know with how much difficulty a child is trained to that action. It has to be learned by a long and painful experience, for the child usually gets a good many tumbles in the course of that part of its education; but, when once acquired, it is as natural as the act of breathing, only it is more directly under the control of the will; yet so completely automatic does it become, that we frequently execute a long series of these movements without any consciousness whatever. You start in the morning,

for instance, to go from your home to your place of employment; your mind is occupied by a train of thought, something has happened which has interested you, or you are walking with a friend, and in earnest conversation with him; and your legs carry you on without any consciousness on your part that you are moving them. You stop at a certain point, the point at which you are accustomed to stop, and very often you will be surprised to find that you are there. While your mind has been intent upon something else, either the train of thought which you were following out in your own mind, or upon what your friend has been saying, your legs move on of themselves, just as your heart beats, or as your muscles of breathing continue to act. But this is an acquired habit; this is what we call a "secondarily automatic" action. Now, that phrase is not very difficult when you understand it. By automatic we mean an action taking place of itself. I dare say most of you have seen automata of one kind or another, such as children's toys and more elaborate pieces of mechanism, which, being wound up with a spring, and containing a complicated series of wheels and levers, execute a variety of movements. In each of the Great Exhibitions there have been very curious automata of this kind. We speak, then, of the actions being "automatic," when we mean that they take place of themselves, without any direction on our own parts; such as the act of sucking in the infant, the acts of respiration and swallowing, and others which are entirely involuntary, and are of this purely reflex character. Now, those are "primarily automatic," that is, originally automatic; we are born with a tendency to execute them; but the actions of the class I am now speaking of are executed by the same portion of the nervous system—the spinal cord—and are "secondarily automatic," that is to say, we have to learn them, but, when once learned, they come very much into the condition of the others, only we have some power of will over them. We start ourselves in the morning by an act of the will; we are determined to go to a particular place; and it may be that we are conscious of these movements over the whole of our walk; but, on the other hand, we may be utterly unconscious of them, and continue to be so until either we have arrived at our journey's end or begin to feel fatigued. Now, when we begin to feel fatigued, we are obliged to maintain the action by an effort of the will; we are no longer unconscious, and we are obliged to struggle against the feeling of fatigue, to exert our muscles in order to continue the action.

Now, having set before you this reflex action of the Spinal Cord, you will ask me perhaps what is the exciting cause of this succession of actions in walking. I believe it is the contact of the ground with the foot at each movement. We put down the foot, that suggests as it were to the spinal cord the next movement of the leg in advance, and that foot comes down in its turn; and so we follow with this regular rhythmical succession of movements.

We next pass to a set of centres somewhat higher, those which form the summit, as it were, of this spinal cord, which are really embedded in the brain, but which do not form a part of that higher organ, which is in fact the organ of the higher part of our mental nature, yet which are commonly included in that which we designate the brain. In fact, the anatomist who only studies the human brain is very liable to be misled in regard to the character of these different parts, by the fact that the higher part—that which we call the Cerebrum—is so immensely developed in Man, in proportion to the rest of the animal creation, that it envelops, as it were, the portion of which I am about to speak, concealing it, and reducing it apparently to the condition of a very subordinate part; and yet that subordinate part is, as I shall show you, the foundation or basis of the higher portion—the Cerebrum itself. The brain of a Fish consists of very little else than a series of these ganglia, these little knots—the word "ganglion" means "knot," and the ganglia in many instances, when separated, are little knots, as it were, upon the nerves. The brain of a fish consists of a series of these ganglia, one pair belonging to each principal organ of sense. Thus we have in front the ganglia of smell, then the ganglia of sight, the ganglia of hearing, and ganglia of general sensation. These constitute almost entirely the brain of the fish. There is scarcely any thing in the brain of the fish which answers to the Cerebrum or higher part of the brain of man. I will give you an idea of the relative development of these parts. [Dr. Carpenter made other sketches on the black-board, to represent these ganglia of sense in man and the lower animals.] Now, the Cerebrum in most fishes is a mere little film, overlying the sensory tract, but in the higher fish we have it larger; in the reptiles we have it larger still; and in birds we have it still larger; in the lower mammalia it is larger still; and then as we ascend to man this part becomes so large in proportion that my board will not take it in. This Cerebrum, this great mass of the brain, at the bottom of which these Ganglia of Sense are buried, as it were, so overlies and conceals them that their essential functions for a long time remained unknown. Now, in the Cerebrum, the position of the active portion, what we call the ganglionic matter, that which gives activity and power to these nervous centres, is peculiar. In all ganglia this "gray" matter, as it is called, is distinct from the white matter. In ordinary ganglia, this gray matter lies in the interior as a sort of little kernel; but in the Cerebrum it is spread out over the surface, and forms a film or layer. If any of you have the curiosity to see what it is like, you have only to get a sheep's brain and examine it, and you will see this film of a reddish substance covering the surface of the Cerebrum. In the higher animals, and in man, this film is deeply folded upon itself, with the effect of giving it a very much more extended surface, and in this manner the blood-vessels come into relation with it; and it is by the changes which take place between this nervous matter and the blood that all

our nervous power is produced. You might liken it roughly to the galvanic battery by which the electric telegraph acts, the white or fibrous portion of the brain and nerves being like the conducting wires of the telegraph. Just as the fibres of the nerves establish a communication between the organs of sensation and the ganglionic centres, and again between the ganglionic centres and the muscles, so do the white fibres, which form a great part of the brain, establish a communication between the gray matter of the convoluted or folded surface of the Cerebrum and the Sensory Ganglia at its base. Now, I believe that this sensory tract which lies at the base of the skull is the real *Sensorium*, that is, the centre of sensation; that the brain at large, the cerebrum, the great mass of which I have been speaking, is not in itself the centre of sensation; that, in fact, the changes which take place in this gray matter only rise to our consciousness—only call forth our conscious mental activity—when the effect of those changes is transmitted downward to this Sensorium. Now, this Sensorium receives the nerves from the organs of sense. Here, for instance, is the nerve from the organ of smell, here from the eye, and here from the body generally (the nerves of touch), and here the nerves of hearing—every one of these has its own particular function. Now, these Sensory ganglia have in like matter reflex actions. I will give you a very curious illustration of one of these reflex actions: You all know the start we make at a loud sound or a flash of light; the stimulus conveyed through our eyes from the optic nerve to the central ganglion causing it to send through the motor nerves a mandate that calls our muscles into action. Now, this may act sometimes in a very important manner for our protection, or for the protection of some of our delicate organs. A very eminent chemist a few years ago was making an experiment upon some extremely explosive compound which he had discovered. He had a small quantity of this compound in a bottle, and was holding it up to the light, looking at it intently; and whether it was a shake of the bottle or the warmth of his hand, I do not know, but it exploded in his hand, the bottle was shivered into a million of minute fragments, and those fragments were driven in every direction. His first impression was, that they had penetrated his eyes, but to his intense relief he found presently that they had only penetrated the outside of his eyelids. You may conceive how infinitesimally short the interval was between the explosion of the bottle and the particles reaching his eyes; and yet in that interval the impression had been made upon his sight, the mandate of the reflex action, so to speak, had gone forth, the muscles of his eyelids had been called into action, and he had closed his eyelids before the particles reached them, and in this manner his eyes were saved. You see what a wonderful proof this is of the way in which the automatic action of our nervous apparatus enters into the sustenance of our lives, and the protection of our most important organs from injury.

Now I have to speak of the way in which this Automatic action of

the Sensory nerves, and of the motor nerves which answer to them, grows up, as it were, in ourselves. We will take this illustration: Certain things are originally instinctive, the tendency to them is born with us; but in a very large number of things we educate ourselves, or we are educated. Take, for instance, the guidance of the class of movements I was speaking of just now—our movements of locomotion. We find that when we set off in the morning with the intention of going to our place of employment, not only do our legs move without our consciousness, if we are attending to something entirely different, but we guide ourselves in our walk through the streets; we do not run up against anybody we meet; we do not strike ourselves against the lamp-posts; and we take the appropriate turns which are habitual to us. It has often happened to myself, and I dare say it has happened to every one of you, that you have intended, to go somewhere else—that when you started you intended instead of going in the direct line to which you were daily accustomed, to go a little out of your way to perform some little commission; but you have got into a train of thought and forgotten yourself, and you find that you are half-way along your accustomed track before you become aware of it. Now, there, you see, is the same automatic action of these sensory ganglia—we see, we hear—for instance, we hear the rumbling of the carriages, and we avoid them without thinking of it—our muscles act in respondence to these sights and sounds—and yet all this is done without our intentional direction—they do it for us. Here again, then, we have the "secondarily automatic" action of this power, that of a higher nervous apparatus which has grown, so to speak, to the mode in which it is habitually exercised. Now, that is a most important consideration. It has grown to the mode in which it is habitually exercised; and that principle, as we shall see, we shall carry into the higher class of Mental operations.

But there is one particular kind of this action of the Sensory nerves to which I would direct your attention, because it leads us to another very important principle. You are all, I suppose, acquainted with the action of the stereoscope; though you may not all know that its peculiar action, the perception of solidity it conveys to us, depends upon the combination of two dissimilar pictures—the two dissimilar pictures which we should receive by our two eyes of an object if it were actually placed before us. If I hold up this jug, for instance, before my eyes, straight before the centre of my face, my two eyes receive pictures which are really dissimilar. If I made two drawings of the jug, first as I see it with one eye, and then with the other, I should represent this object differently. For instance, as seen with the right eye, I see no space between the handle and the body of the jug; as I see it with the left eye, I see a space there. If I were to make two drawings of that jug as I now see it with my two eyes, and put them into a stereoscope, they would bring out, even if only in outline, the

conception of the solid figure of that jug in a way that no single drawing could do. Now, that conception is the result of our early-acquired habit of combining with that which we *see* that which we *feel*. That habit is acquired during the first twelve or eighteen months of infancy. When your little children are lying in their cradles and are handling a solid object, a block of wood, or a simple toy, and are holding it at a distance from their eyes, bringing it to their mouth and then carrying it to arm's length, they are going through a most important part of their education—that part of their education which consists in the harmonization of the mental impressions derived from sight and those derived from the touch; and it is by that harmonization that we get that conception of solidity or projection which, when we have once acquired it, we receive from the combination of these two dissimilar pictures alone, or even, in the case of objects familiar to us, without two dissimilar pictures at all—the sight of the object suggesting to us the conception of its solidity and of its projection.

Now, this is a thing so familiar to you, that few of you have probably ever thought of reasoning it out; and in fact it has only been by the occurrence of cases in which persons have grown to adult age without having acquired this power, from having been born blind and having only received sight by a surgical operation at a comparatively late period, when they could describe things as they saw them—I say it is only by such cases that we have come to know how completely dissimilar and separate these two classes of impressions really are, and how important is this process of early infantile education of which I have spoken. A case occurred a few years ago in London where a friend of my own performed an operation upon a young woman who had been born blind, and, though an attempt had been made in early years to cure her, that attempt had failed. She was able just to distinguish large objects, the general shadow, as it were, of large objects without any distinct perception of form, and to distinguish light from darkness. She could work well with her needle by the touch, and could use her scissors and bodkin and other implements by the training of her hand, so to speak, alone. Well, my friend happened to see her, and he examined her eyes, and told her that he thought he could get her sight restored; at any rate, it was worth a trial. The operation succeeded; and, being a man of intelligence and quite aware of the interest of such a case, he carefully studied and observed it; and he completely confirmed all that had been previously laid down by the experience of similar cases. There was one little incident which will give you an idea of the education which is required for what you would suppose is a thing perfectly simple and obvious. She could not distinguish by sight the things that she was perfectly familiar with by the touch, at least when they were first presented to her eyes. She could not recognize even a pair of scissors. Now, you would have supposed that a pair of scissors, of all things in the world, having been

continually used by her, and their form having become perfectly familiar to her hands, would have been most readily recognized by her sight; and yet she did not know what they were; she had not an idea until she was told, and then she laughed, as she said, at her own stupidity. No stupidity at all; she had never learned it, and it was one of those things which she could not know without learning. One of the earliest cases of this kind was related by the celebrated Cheselden, a surgeon of the early part of last century. Cheselden relates how a youth just in this condition had been accustomed to play with a cat and a dog; but for some time after he attained his sight he never could tell which was which, and used to be continually making mistakes. One day being rather ashamed of himself for having called the cat the dog, he took up the cat in his arms and looked at her very attentively for some time, stroking her all the while; and in this way he associated the impression derived from the sight of the cat with the impression derived from the touch, and made himself master (so to speak) of the whole idea of the animal. He then put the cat down, saying, "Now, puss, I shall know you another time."

Now, the reason why I have specially directed your attention to this is because it leads to one of the most important principles that I desire to expound to you this evening—what I call in Mental Physiology the doctrine of *resultants*. All of you who have studied mechanics know very well what a "resultant" means. You know that when a body is acted on by two forces at the same time, one force carrying it in this direction, and another force in that direction, we want to know in what direction it will go, and how far it will go. To arrive at this we simply complete what is called the parallelogram of forces. In fact, it is just as if a body were acted on at two different times, by a force driving it in one direction, and then by a force driving it in the other direction. [Dr. Carpenter illustrated this point by the aid of the black-board.] We draw two lines parallel to this, and we draw a diagonal—that diagonal is what is called the resultant; that is, it expresses the direction, and it expresses the distance—the length of the motion which that body will go when acted upon by these two forces. Now, I use this term as a very convenient one to express this—that when we have once got the conception that is derived from the harmonization of these two distinct sets of impressions on our nerves of sense, we do not fall back on the original impressions, but we fall back on the resultant, so to speak. The thing has been done for us; it is settled for us; we have got the resultant; and the combination giving that resultant is that which governs the impression made upon our minds by all similar and future operations of the same kind. We do not need to go over the processes of judgment by which the two sets of impressions are combined in every individual case; but we fall back, as it were, upon the resultant. Now, what is the case in the harmonization of the two classes of impressions of sight and touch, I believe to

be true of the far more complicated operations of the mind of which the higher portion of the brain, the Cerebrum, is the instrument. Now, this Cerebrum we regard as furnishing, so to speak, the mechanism of our thoughts. I do not say that the Cerebrum is that which does the whole work of thinking, but it furnishes the mechanism of our thought. It is not the steam-engine that does the work; the steam-engine is the mere mechanism; the work is done, as my friend Prof. Roscoe would tell you, by the heat supplied; and if we go back to the source of that heat, we find it originally in the heat and light of the sun that made the trees grow by which the coal was produced, in which the heat of the sun is stored up, as it were, and which we are now using, I am afraid, in rather wasteful profusion. The steam-engine furnishes the mechanism; the work is done by the force. Now, in the same manner the brain serves as the mechanism of our thought; and it is only in that sense that I speak of the work of the brain. But there can be no question at all that it works of itself, as it were,—that it has an automatic power, just in the same manner as the sensory centres and the spinal cord have automatic power of their own. And that a very large part of our mental activity consists of this automatic action of the brain, according to the mode in which we have trained it to action, I think there can be no doubt whatever. And the illustration with which I started in this lecture gives you, I believe, a very good example of it. However, there are other examples which are in some respects still better illustrations of the automatic work that is done by the brain, in the state which is sometimes called Second Consciousness or Somnambulism—to which some persons are peculiarly subject. I heard only a few weeks ago of an extremely remarkable example of a young man who had overworked himself in studying for an examination, and who had two distinct lives, as it were, in each of which his mind worked quite separately and distinct from the other. One of these states, however—the ordinary one—is under the control of the will to a much greater extent than the other; while the secondary state is purely, I suppose, automatic. There are a great many instances on record on very curious mental work, so to speak, done in this automatic condition—a state of active dreaming, in fact. For instance, Dr. Abercrombie mentions, in his very useful work on "The Intellectual Powers," an example of a lawyer who had been excessively perplexed about a very complicated question. An opinion was required from him, but the question was one of such difficulty that he felt very uncertain how his opinion should be given. The opinion had to be given on a certain day, and he awoke in the morning of that day with a feeling of great distress. He said to his wife, "I had a dream, and the whole thing in that dream has been clear before my mind, and I would give any thing to recover that train of thought." His wife said to him, "Go and look on your table." She had seen him get up in the night and go to his table and sit down and write. He went to his table,

and found there the very opinion which he had been most earnestly endeavoring to recover, lying in his own handwriting. There was no doubt about it whatever, and this opinion he at once saw was the very thing which he had been anxious to be able to give. A case was put on record of a very similar kind only a few years ago by a gentleman well known in London, the Rev. John De Liefde, a Dutch clergyman. This gentleman mentioned it on the authority of a fellow-student who had been at the college at which he studied in early life. He had been attending a class in mathematics, and the professor said to his class one day: "A question of great difficulty has been referred to me by a banker, a very complicated question of accounts, which they have not themselves been able to bring to a satisfactory issue, and they have asked my assistance. I have been trying, and I cannot resolve it. I have covered whole sheets of paper with calculations, and have not been able to make it out. Will you try?" He gave it as a sort of problem to his class, and said he should be extremely obliged to any one who would bring him the solution by a certain day. This gentleman tried it over and over again; he covered many slates with figures, but could not succeed in resolving it. He was a little put on his mettle, and very much desired to attain the solution; but he went to bed on the night before the solution, if attained, was to be given in, without having succeeded. In the morning, when he went to his desk, he found the whole problem worked out in his own hand. He was perfectly satisfied that it was his own hand; and this was a very curious part of it—that the result was correctly obtained by a process very much shorter than any he had tried. He had covered three or four sheets of paper in his attempts, and this was all worked out upon one page, and correctly worked, as the result proved. He inquired of his "hospita," as she was called—I believe our English equivalent is bedmaker, the woman who attended to his rooms—and she said she was certain that no one had entered his room during the night. It was perfectly clear that this had been worked out by himself.

Now, there are many cases of this kind, in which the mind has obviously worked more clearly and more successfully in this automatic condition, when left entirely to itself, than when we have been cudgelling our brains, so to speak, to get the solution. I have paid a good deal of attention to this subject, in this way: I have taken every opportunity that occurred to me of asking inventors and artists—creators in various departments of art—musicians, poets, and painters, what their experience has been in regard to difficulties which they have felt, and which they have after a time overcome. And the experience has been almost always the same, that they have set the result which they have wished to obtain strongly before their minds, just as we do when we try to recollect something we have forgotten; they think of every thing that can lead to it; but, if they do not succeed, they put it by for a time, and give their minds to something else, and endeavor to ob-

tain as complete a repose or refreshment of the mind upon some other occupation as they can; and they find that either after sleep, or after some period of recreation by a variety of employment, just what they want comes into their heads. A very curious example of this was mentioned to me a few years ago by Mr. Wenham, a gentleman who has devoted a great deal of time and attention to the improvement of the microscope, and who is the inventor of that form of binocular microscope (by which we look with two eyes and obtain a stereoscopic picture) which is in general use in this country. The original binocular microscope was made upon a plan which would suggest itself to any optician. I shall not attempt to describe it to you, but it involved the use of three prisms, giving a number of reflections; and every one of these reflections was attended with a certain loss of light and a certain liability to error. And, besides that, the instrument could only be used as a binocular microscope. Now, Mr. Wenham thought it might be possible to construct an instrument which would work with only one prism, and that this prism could be withdrawn, and then we could use the microscope for purposes to which the binocular microscope could not be applied. He thought of this a great deal, but he could not think of the form of prism which would do what was required. He was going into business as an engineer, and he put his microscopic studies aside for more than a fortnight, attending only to his other work, and thinking nothing of his microscope. One evening after his day's work was done, and while he was reading a stupid novel, as he assured me, and was thinking nothing whatever of his microscope, the form of the prism that should do this work flashed into his mind. He fetched his mathematical instruments, drew a diagram of it, worked out the angles which would be required, and the next morning he made his prism, and found it answered perfectly well; and upon that invention nearly all the binocular microscopes made in this country have since been constructed.

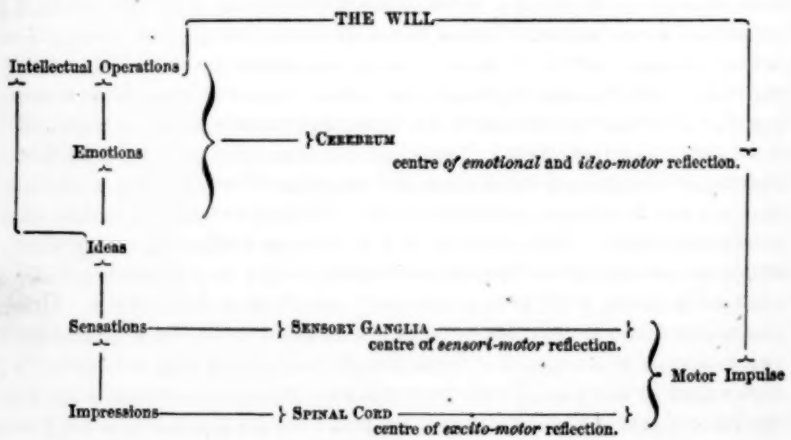
I could tell you a number of anecdotes of this kind which would show you how very important is this automatic working of our minds—this work which goes on without any more control or direction of the Will, than when we are walking and engaged in a train of thought which makes us unconscious of the movements of our legs. And I believe that in all these instances—such as those I have named, and a long series of others—the result is owing to the mind being left to itself without the disturbance of any emotion. It was the worry which the bank-manager had been going through, that really prevented the mind from working with the steadiness and evenness that produced the result. So in the case of the lawyer; so in the case of the mathematician; they were all worrying themselves, and did not let their minds have fair play. You have heard, I dare say, and those of you who are horsemen may have had experience, that it is a very good thing sometimes, if you lose your way on horseback, to drop the reins on the

horse's back and let him find his way home. You have been guiding the horse into one path and into another, and following this and that path, and you find that it does not lead you in the right direction; just let the horse go by himself, and he will find his way better than you can. In the same manner, I believe that our minds, under the circumstances I have mentioned, really do the work better than our wills can direct. The will gives the impulse in the first instance, just as when you start on your walk; and not only this, but the will keeps before the mind all the thoughts which it can immediately lay hold of, or which association suggests, that bear upon the subject. But then these thoughts do not conduct immediately to an issue, they require to work themselves out; and I believe that they work themselves out very often a great deal better by being left to themselves. But then we must recollect that such results as these are only produced in the mind which has been trained and disciplined; and that training and discipline are the result of the control of the Will over the mental processes, just as in the early part of the lecture I spoke to you of the act of speech as made possible by the control which the will has over the muscles of breathing. We cannot stop these movements—we must breathe—but we can regulate them, and modify them, and intensify them, or we can check them for a moment, in accordance with the necessities of speech. Well, so it is, I think, with regard to the action of our will upon our mental processes. I believe that this control, this discipline of the will, should be learned very early; and I will give to the mothers among you, especially, one hint in regard to a most valuable mode of training it even in early childhood. I learned this, I may say, from a nurse whom I was fortunate enough to have, and whose training of my own sons in early childhood I regard as one of the most valuable parts of their education. She was a sensible country girl, who could not have told her reasons, but whose instincts guided her in the right direction. I studied her mode of dealing with the children, and learned from that the principle. Now, the principle is this: A child falls down and hurts itself. (I take the most common of nursery incidents. You know that Sir Robert Peel used to say that there were three ways of looking at this question; and there are three modes of dealing with this commonest of nursery incidents.) One nurse will scold the child for crying. The child feels the injustice of this; it feels the hurt, and it feels the injustice of being scolded. I believe that is the most pernicious of all the modes of dealing with it. Another coddles the child, takes it up and rubs its head, and says, "O naughty chair, for hurting my dear child!" I remember learning that one of the royal children fell against a table in the queen's presence, and the nurse said, "O naughty table," when the queen very sensibly said: "I will not have that expression used; it was not the table that was naughty; it was the child's fault that he fell against the table." I believe that this method is extremely injurious; the result of it being

that it fixes the child's attention upon its hurt, and causes it to attain that habit of self-consciousness which is in after-life found to have most pernicious effects. Now, what does the sensible and judicious nurse do? She distracts the child's attention, holding it up to the window to look at the pretty horses, or gets it a toy to look at. This excites the child's attention, and the child forgets its hurt, and in a few moments is itself again, unless the hurt has been severe. When I speak of coddling, I mean about a trifling hurt such as is forgotten in a few moments; a severe injury is a different matter. But I believe that the coddling is only next in its evil results (when followed out as a system) to the evil effects of the system of scolding; the distraction of the attention is the object to be aimed at. Well, after a time the child comes to be able to distract its own attention. It feels that it can withdraw its own mind from the sense of its pain, and can give its mind to some other object, to a picture-book or to some toy, or whatever the child feels an interest in; and that is the great secret of self-government in later life. We should not say, "I won't think of this"—some temptation, for instance; *that* simply fixes the attention upon the very thought that we wish to escape from; but the true method is, "I will think of something else;" *that*, I believe, is the great secret of self-government, the knowledge of which is laid in the earliest periods of nursery-life.

Now, just direct your attention to this diagram, as a sort of summary of the whole:

[DIAGRAM.]



You see I put at the top the Will. The will dominates every thing else. I do not pretend to explain it, but I simply say, as Archbishop Manning said, in applying my own language to this case, that our common-sense teaches us that we have a will, that we have the power of self-government and self-direction, and that we have the power of

regulating and dominating all these lower tendencies to a certain extent, not to an unlimited extent. We cannot prevent those thoughts and feelings rising in our minds that we know to be undesirable; but we can escape from them, we can repress them; but, as I said, the effort to escape from them is much more effectual than the effort to repress them, excepting when they arise with great power, and then we have immediately, as it were, to crush them out; but when they tend to return over and over again, the real mode of subduing them is to determine to give our attention to something else. It is by this exercise of the will, therefore, in training and disciplining the mind, that it acquires that method by which it will work of itself. The mathematician could never have worked out that difficult problem, nor the lawyer have given his opinion, nor the artist have developed those conceptions of beauty which he endeavors to shape either in music, or poetry, or painting, but for the training and disciplining which his mind has undergone. The most wonderfully creative of all musicians, Mozart, whose music flowed from him with a spontaneousness that no musician, I think, has ever equalled—Mozart went through, in early life, a most elaborate course of study, imposed upon him, in the first instance, by his father, and afterward maintained by himself. When his contemporaries remarked how easily his compositions flowed from him, he replied, "I gained the power by nothing but hard work." Mozart had the most extraordinary combination of this intuitive musical power, with a knowledge derived from patient and careful study, that probably any man ever attained. Now, in the same manner we have persons of extraordinary natural gifts, and see these gifts frequently running to waste, as it were, because they have not received this culture and discipline. And it is this discipline which gives us the power of performing, unconsciously to ourselves, these elaborate mental operations; because I hold that a very large part of our mental life thus goes on, not only automatically, but even below the sphere of our consciousness. And you may easily understand this if you refer to the diagram which I drew just now on the black-board. You saw that the Cerebrum, the part that does the work, what is called the convoluted surface of the brain, lies just immediately under the skull-cap; that it is connected with the sensorium at the base of the brain by a series of fibres which are merely, I believe, conducting fibres. Now, I think that it is just as possible that the Cerebrum should work by itself when the sensorium is otherwise engaged or in a state of unconsciousness, as that impressions should be made on the eye of which we are unconscious. A person may be sleeping profoundly, and you may go and raise the lid and bring a candle near, and you will see the pupil contract; and yet that individual shall see nothing, for he is in a state of perfect unconsciousness. His eye sees it, so to speak, but his mind does not; and you know that his eye sees it by the contraction of the pupil, which is a reflex action; but his mind does not see it, because the sensorium is

in a state of inaction. In the same manner during sleep the Cerebrum may be awake and working, and yet the Sensorium shall be asleep, and we may know nothing of what the cerebrum is doing except by the results. And it is in this manner, I believe, that, having been once set going, and the cerebrum having been shaped, so to speak, in accordance with our ordinary processes of mental activity, having grown to the kind of work we are accustomed to set it to execute, the cerebrum can go on and do its work for itself. The work of invention, I am certain, is so mainly produced, from concurrent testimony I have received from a great number of inventors, or what the old English called "makers"—what the Greeks called poets, because the word poet means a maker. Every inventor must have a certain amount of imagination, which may be exercised in mechanical contrivance or in the creations of art; these are *inventions*—they are made, they are produced, we don't know how; the conception comes into the mind we cannot tell whence; but these inventions are the result of the original capacity for that particular kind of work, trained and disciplined by the culture we have gone through. It is not given to every one of us to be an inventor. We may love art thoroughly, and yet we may never be able to evolve it for ourselves. So in regard to humor. For instance, there are some men who throw out flashes of wit and humor in their conversation, who cannot help it—it flows from them spontaneously. There are other men who enjoy this amazingly, whose nature it is to relish such expressions keenly, but who cannot make them themselves. The power of invention is something quite distinct from the intellectual capacity or the emotional capacity for enjoying and appreciating; but although we may not have these powers of invention, we can all train and discipline our minds to utilize that which we do possess to its utmost extent. And here is the conclusion to which I would lead you in regard to Common-Sense. We fall back upon this, that common-sense is, so to speak, the *general resultant of the whole previous action of our minds.* We submit to common-sense any questions—such questions as I shall have to bring before you in my next lecture; and the judgment of that common-sense is the judgment elaborated as it were by the whole of our mental life. It is just according as our mental life has been good and true and pure, that the value of this acquired and this higher common-sense is reached. We may in proportion I believe to our honesty in the search for truth—in proportion as we discard all selfish considerations and look merely at this grand image of truth, so to speak, set before us, with the purpose of steadily pursuing our way toward it—in proportion as we discard all low and sensual feelings in our love of beauty, and especially in proportion to the earnestness of the desire by which our minds are pervaded always to keep the right before us in all our judgments—so I believe will our minds be cleared in their perception of what are merely prudential considerations. It has on several occasions occurred to me to form a

decision as to some important change either in my own life, or in the life of members of my family, which involved a great many of what we are accustomed to call *pros* and *cons*—that is, there was a great deal to be said on both sides. I heard the expression once used by a naturalist, with regard to difficulties in classification—"It is very easy to deal with the white and the black; but the difficulty is to deal with the gray." And so it is in life. It is perfectly easy to deal with the white and the black—there are things which are clearly right, and things which are clearly wrong; there are things which are clearly prudent, and things which are clearly imprudent; but a great many cases arise in which even right and wrong may seem balanced, or the motives may be so balanced that it is difficult to say what is right; and again, there are cases in which it is difficult to say what is prudent; and I believe, in these cases where we are not hurried and pressed for a decision, the best plan is to do exactly that which I spoke of in the earlier part of the lecture—to set before us as much as possible every thing that is to be said on both sides. Let us consider this well; let us go to our friends; let us ask what they think about it. They will suggest considerations which may not occur to ourselves. It has happened to me within the last three or four months to have to make a very important decision of this kind for myself; and I took this method—I heard every thing that was to be said on both sides, I considered it well, and then I determined to put it aside as completely as possible for a month, or longer, if time should be given, and then to take it up again, and simply just to see how my mind gravitated—how the balance then turned. And I assure you that I believe that in those who have disciplined their minds in the manner I have mentioned, that act of "Unconscious Cerebration," for so I call it, this unconscious operation of the brain in balancing for itself all these considerations, in putting all in order, so to speak, in working out the result—I believe that that process is far more likely to lead us to good and true results than any continual discussion and argumentation, in which one thing is pressed with undue force, and then that leads us to bring up something on the other side, so that we are just driven into antagonism, so to speak, by the undue pressure of the force which we think is being exerted. I believe that to hear every thing that is to be said, and then not to ruminate upon it too long, not to be continually thinking about it, but to put it aside entirely from our minds as far as we possibly can, is the very best mode of arriving at a correct conclusion. And this conclusion will be the *resultant* of the whole previous training and discipline of our minds. If that training and discipline has all been in the direction of the true and the good, I believe that we are more likely to obtain a valuable result from such a process than from any conscious discussion of it in our minds, any thing like continually bringing it up and thinking of it, and going over the whole subject again in our thought. The unconscious settling down, as it were, of all these respective motives will,

I think, incline the mind ultimately to that which is the just and true decision.

There is just one other point I could mention in connection with this subject: the manner in which the *conscious* direction and discipline of the mind will tend to remove those *unconscious* prejudices that we all have more or less from education, from the circumstances in which we were brought up; and from which it is excessively difficult for us to free ourselves entirely. I have known a great many instances, in public and in private life, in which the most right-minded men have every now and then shown the trammelling, as it were, of their early education and early associations, and were not able to think clearly upon the subject in consequence of this. These early prejudices and associations cling around us and influence the thoughts and feelings of the honestest men in the world unconsciously; and it is sometimes surprising, to those who do not know the force of these early associations, to see how differently matters which are to them perfectly plain and obvious are viewed by men whom we feel we must respect and esteem. Now, I believe that it is the earnest habit of looking at a subject from first principles, and, as I have said over and over again, looking honestly and steadily at the true and the right, which gives the mind that direction that ultimately overcomes the force of these early prejudices and these early associations, and brings us into that condition which approaches the nearest of any thing that I think we have the opportunity of witnessing in our earthly life, to that *direct insight*, which many of us believe will be the condition of our minds in that future state in which they are released from all the trammels of our corporeal existence.

THE PAST AND FUTURE OF NIAGARA.

By Prof. W. D. GUNNING.

IN October, 1842, the Falls of Niagara were made the subject of careful study by the New York State Geologists. Under their direction a trigonometrical survey was made, and the river-banks—ancient and recent—the contours of Goat and Luna and Bath Islands, and the periphery of the Falls, were mapped with the utmost precision. The map is preserved in the archives of the State, at Albany, and the copper bolts and little stone monuments, which were placed to mark the trigonometrical points, remain—all, except those which fell with Table Rock. The American Association for the Advancement of Science, at its session last summer, petitioned the New York Legislature to provide for another survey. The expense would have been a mere trifle, but gentlemen of "the Reform Legislature" would not even consider the

proposition. It is to be lamented, for another survey would give data by which we could translate into time nearly half a mile of the channel. Until the Falls shall be examined again by instrumentation, in estimating the rate of recession we must depend on the eye alone.

In 1840 old citizens told Lyell that the Falls recede about a yard in a year. I hear the same estimate from citizens now. They see a notch in the Horseshoe which was not there thirty years ago, and they see it growing deeper year by year; they see the American Fall more indented than it was when they used to observe it, and from such changes they construct a scale and apply it to the entire periphery. They deceive themselves. A careful study of the Falls from the trigonometrical points, even without instruments, and a comparison of what you see, with the map of 1842, would convince you that the recession during the past 30 years would fall inside of 15 feet. Let us take six inches a year as an approximation to the rate at which the Falls are eating back through the ledges of shale and limestone. The scale which answers to the last 30 years will apply to the channel from the Horseshoe to Ferry Landing, nearly half a mile. Through this part of the channel the Falls have cut through the same rocks they are cutting now. When they were at the site of Ferry Landing, a hard limestone, a member of the Clinton group, No. 4 of our section (Fig. 1), lay at their base, and the recession must have been arrested. Again, when they were at the site of the Whirlpool, a very hard, quartzose sandstone, marked 2 in the section, a member of the Medina system, lay at their base and checked their recession. Here the great cataract must have stood for ages almost stationary. With these two exceptions, the Falls, in every stage of their retreat, have cut through shale below, and the Niagara limestone above.

FIG. 1.

SECTION OF STRATA ALONG THE RIVER FROM LAKE TO LAKE.

Numbers 1, 2, 3, belong to the Medina group; 4, to the Clinton group; 5, 6, 7, to the Niagara group; and 8 and 9 to the Onondaga group. Numbers 1 and 3 are red shaly sandstone; 2 is quartzose limestone; 4 green shale and limestone; 5 dark shale; and 6 gray limestone. W, site of the Whirlpool, where the Falls were 120 feet higher than now, and where their recession was checked by the quartzose sandstone, No. 2. The dotted line *t*, *t*, represents the highest terrace (or oldest river-bank) from the Whirlpool to the head of the Rapids, H. F represents the present site of the Falls, and R, R, the surface of the river from lake to lake.

Another element in the problem of Niagara's age is the flow of water. To construct a scale from the present and apply it to the past, we should know that the amount of water in past ages has been essentially the same as now.

About 9,800 cubic miles of water—nearly half the fresh water on the globe—are in the upper lakes, and 18,000,000 cubic feet of this

plunge over Niagara Falls every minute, all the water of the lakes making the circuit of the Falls, the St. Lawrence, the ocean, vapor, rain, and lakes again, in 152 years. Through the Illinois Canal about 8,000 cubic feet of water are taken every minute from Lake Michigan to the Illinois River; through the Welland Canal 14,000 cubic feet flow every minute from Lake Erie into Lake Ontario, and through the Erie Canal 30,000 cubic feet pass every minute from the same lake into the Hudson. Thus, 52,000 cubic feet of water, which Nature would give to Niagara, are diverted every minute by artificial channels, some into the Mexican Gulf and some into the Bay of New York. Add this to 18,000,000, it is as a drop in the bucket, and would make no appreciable difference in the character of the Falls or their rate of recession. Was there *ever* a time when the Niagara was appreciably a greater river than now?

Below the Falls, on the Canada side, is a terrace, extending along the river-bank, and attaining a height of 46 feet. It contains river-shells, and is an old river-bank. A corresponding bank is found on the New York side, although much broken and eroded. If a tourist will stand on the New Suspension Bridge and cast his eye along these ancient banks, his first impression will be that the Niagara which flowed against them was vastly greater than the river which flows now nearly 200 feet below him. But, if his eye will follow the Canadian terrace above the Horseshoe, he will see it falling lower and lower, till, at the head of the Rapids, it merges into the present bank. From this point upward the river is contained within low banks, and bounded by a plain whose monotony is not broken by a hill or terrace. A glance at the section (Fig. 1) will make this clear to the eye of the reader. The surface of the river from Buffalo to Lake Ontario is represented by the line R, R; the banks, from Buffalo to the Rapids, by the dotted line *t*, *t*; and the *old* banks, from the Rapids to the Whirlpool, by a continuation of the same line. It will be seen that this line rises as the surface of the river falls. The slope from the head of the Rapids to the Falls is nearly 50 feet, and the terrace opposite the Falls attains a height of 46 feet.

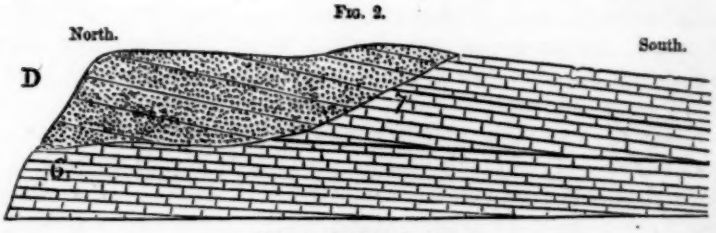
We turn now to Goat Island. A walk around the island, by the margin of the river, will show us what immense denudation its limestones have suffered. The extent of this denudation can be seen in our section of the island (Fig. 2). To wear away such beds of limestone, the river, for many ages, must have flowed over the island. And as the upper beds of fluviatile drift, marked D in our section, are a little below the level of the highest terrace, we must infer that the river, when contained in these ancient banks, covered the island, and was eroding its beds of limestone.

By all this we see that the Niagara itself has made the Rapids, and that, as it cut its way downward, its forsaken banks have assumed the character of terraces. And we see, by the low banks and absence

of old banks above the Rapids, that even the highest of these ancient banks did not contain a greater river than this which flows through the narrow gorge to-day.

We assume, then, from all the monuments the river has left of its own history, that the present rate of recession would be a fair measure of the past, except at the Whirlpool and Ferry Landing. Six inches a year, measured on the channel, would place the Falls at Lewiston 74,000 years ago. We have no means of knowing how long the quartzose sandstone, which forms the lowest part of the bank at the Whirlpool, would have arrested the cataract. This stratum is 25 feet thick, and, as its southward dip is 20 feet a mile, and the slope of the river-channel 15 feet a mile, the Falls would have to cut back through this rock more than half a mile. The halt may have been many thousand years. Add another period for the halt at the landing,

FIG. 2.



SECTION OF GOAT ISLAND.

No. 6, the Niagara limestone (6 also of Fig. 1); No. 7, the shaly limestone (marked 7 in Fig. 1). The Rapids have been formed by the erosion of this limestone. D, alluvial drift covering the eroded limestone. The section will show how great had been the denudation of the limestone by the river before the drift D accumulated, and before the river had found its present level.

and the age of the channel, from Lewiston to the Horseshoe, may not fall below 200,000 years. Unquestionably the channel has been excavated since the close of the glacial epoch, which science has wellnigh demonstrated occurred about 200,000 years ago. But this channel is only the last chapter in the history of Niagara.

Standing by the Whirlpool on the east, and looking over the river, we see a break in the ledges of rock which everywhere else form the bank. On the western side, around the bend of the Whirlpool, for a distance of 500 feet, bowlders and gravel take the place of ledges of rock. Many of these bowlders are granite and greenstone and gneiss, which have travelled hundreds of miles from the northeast. This mass of northern drift fills an old river-channel, which we can trace from the Whirlpool to the foot of the escarpment at St. David's—about two miles and a half. The reader will see by the map (Fig. 4) that this old channel marked 13 lies in a line with the present channel above the Whirlpool. The opening at St. David's is two miles wide. Here the Falls stood "in the beginning," wide, but not deep. They had cut back two miles and a half when the glacial period came, and lakes and rivers, and the great cataract, were buried under a colossal

sheet of ice. If we can trust astronomical data (Stone's Tables of the Eccentricity of the Earth's Orbit), the glacial epoch lasted about 50,000 years. Add this to the age of the present channel, and 25,000 years for the preglacial channel, and we have 275,000 years as an approximation to the age of Niagara River.

Of course these figures are given merely as an approximation to the truth. To the general reader the time seems immense. But to the geologist it seems short, and his concern is to account for the æons in which the lakes and their water-shed must have stood above the ocean, but which the Niagara has not registered. Let us attend for a little while to the earlier history of this Niagara region.

From the Old Suspension Bridge three geologic systems can be seen on the river-banks. The lowest is a red, mottled, shaly sandstone, the *Medina sandstone.* It is marked 3 on the section (Fig. 1). Above this, and having the same dip, is a thin group of green shale and gray limestone, the *Clinton group*, No. 4 of the section. Overlying the Clinton is dark shale, and over the shale a thick band of gray limestone, the two forming the *Niagara group*, designated on the section by Nos. 5 and 6.

Below the escarpment at Lewiston, as the diagram will show, the lowest member of the Medina sandstone (No. 1, Fig. 1) appears as the surface rock. We find it ripple-marked and carrying the *Lingula cuneata* and *Fucoides Harlani*, its characteristic shell and sea-weed. It underlies a good part of Western New York and Canada, and extends southward into Pennsylvania and Virginia, with everywhere the same characters, indicating a quiet, shallow sea, fed by rivers which for ages brought down the same sediments. It is eighth in the series of palæozoic rocks which form the first volume of the world's history after the beginnings of life, and is the oldest rock which shows itself about the Falls.

Up the river, about two miles from Lewiston, the railroad, which descends the river-bank, takes us to the junction of the Medina sandstone with the Clinton group. The green shale is barren here, but at Lockport we have found it full of *Agnostus lotus*, a little ill-defined crustacean. The overlying limestone is exceedingly rich in fossils, *Atrypa neglecta* being the characteristic shell. The sea had changed both its life and the rock material on its bottom.

Another change, and to the Clinton succeeded the Niagara period. The change was not abrupt, for many species, common in the Clinton sea, lived in the Niagara as well.

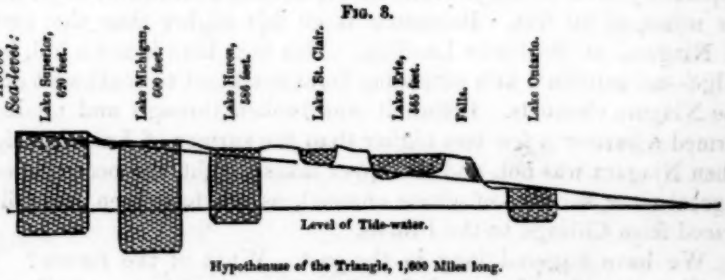
In the Niagara shale we have found *Conularia Niagarensis*, a shell which must be referred to a Pteropod mollusk. Pteropods of the living world are seen only on mid-ocean. They flap themselves over the water by wing-like appendages from the side to the head. Their shells do not drift ashore, but the dredge has brought them up from the ooze of the deep-sea bottom. Now, this Niagara shale is only the hardened

ooze of an ancient sea-bottom, and the *Conularia* tells us that here the sea was open and deep.

A time came when mud-sediments were no longer brought down, and the bottom of an ocean, clear, warm, placid, over an area which extended from the Hudson far beyond the Mississippi, was a vast grove of coral. In sheltered nooks of the coral-grove were gardens of waving crinoids, and three-lobed, many-jointed, many-eyed trilobites were crawling over the coral sand, and mollusks in richly-sculptured shells were everywhere on sand and coral. The Niagara limestone is a monument of that ancient life. With the formation of this rock and its uplift from the sea, the geologic record here about Niagara closed, until the coming of the Ice.

We turn now to the geology of the lake-region. The area of the lakes is estimated at 90,000 square miles; and the area whose streams flow into the lakes, at 400,000 square miles. This immense area is one of the oldest on the globe. On the north shore of Lake Huron and Lake Superior we find the azoic rocks, and on the borders of Lake Erie and Lake Michigan we find no rock newer than the lowest members of the Devonian. The whole water-shed of the St. Lawrence was reclaimed from the ocean before the close of the Devonian epoch. If the drainage has always been through the gulf of St. Lawrence, the Niagara should be one of the oldest rivers on the globe. And yet, as we have seen, in the geological calendar it is very young. How shall we account for this gap between ocean-history and river-history? A little more of geology and something of topography will help us to understand why the Niagara has recorded such a small segment of the time which lies between us and the Devonian seas.

FIG. 3.



IDEAL SECTION OF THE ST. LAWRENCE AND ITS LAKES.

Borings made a few years ago at La Salle, on the Illinois, revealed the fact that the valley had been eroded forty feet below the present river-bed. Pot-holes and water-worn ledges at Athens mark the course of an ancient river. Other evidences of the ancient river are found in the valley of the Des Plaines and along the Calumet feeder of the Illinois Canal.

The topography of the lake-basins and the Niagara plateau will explain that old river-bed.

Lake Erie, as everybody knows, and as we have indicated in the ideal section of the St. Lawrence and its lakes (Fig. 3), fills a shallow basin eroded in a plateau 333 feet above the level of Lake Ontario, and 565 feet above the ocean. The surface of Lake Michigan is 600 feet above tide-level, and, as the lake is 1,000 feet deep, its bottom is 400 feet below the level of tide-water. Lake Superior is 900 feet deep, and its surface about 20 feet above that of Lake Michigan. The Niagara, from Buffalo to the head of the Rapids, has a fall of 15 feet. The fall from Lake Michigan to Goat Island is 50 feet—just equal to the slope of the Rapids. A barrier 15 feet high, stretching across the plateau at the head of the Rapids, would throw the river back on Lake Erie, and such a barrier, 50 feet high, would hold back the waters of Lake Michigan.

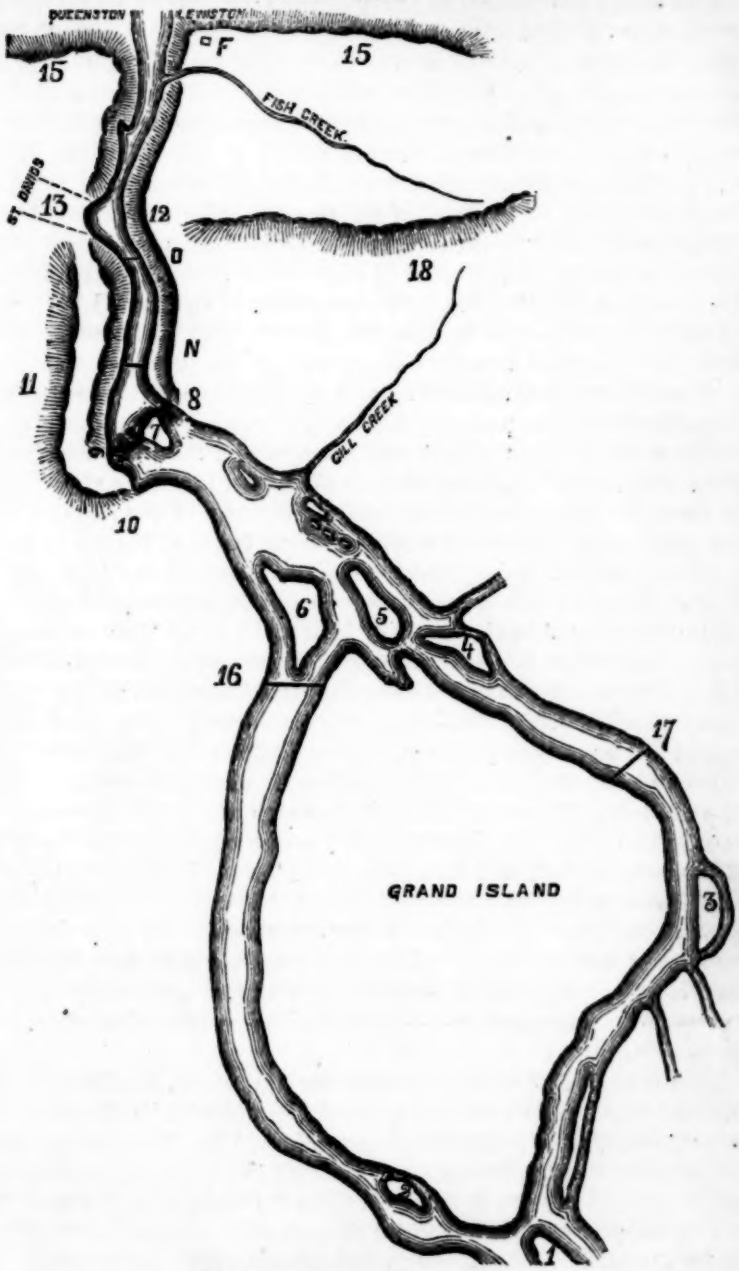
We can see the significance, now, of a few features of topography about the Falls.

The reader will turn to the map of Niagara River, which we have drawn, with some modifications, from the official maps of the Boundary Commission. He will see that, from the foot of Grand Island to the Falls, the course of the river is almost due west. At the Falls it makes an elbow, and extends thence, with no abrupt winding except at the Whirlpool, northward to Lake Ontario. At Schlosser Landing, about a mile above the Rapids, a stream called Gill Creek empties into the river. It is not more than six miles long, and its course is parallel to that of Niagara below the Falls. Its source is a swamp about two miles east of the river, and nearly the same distance north of Old Fort Gray. We have the anomaly of two streams flowing side by side, within two miles of each other, in opposite directions, and through an apparently level country. Gill Creek, flowing southward, has a fall in six miles, of 60 feet. Its source is 60 feet higher than the surface of Niagara at Schlosser Landing. This high land is not a hill, but a ridge—an anticlinal axis extending from northeast to southwest across the Niagara channels. Before it was broken through and eroded, it formed a barrier a few feet higher than the surface of Lake Michigan. Then Niagara was not, and the upper lakes sought the ocean through a great river, sections of whose channel, as we have seen, can still be traced from Chicago to the Illinois.

We have lingered long in the past. What of the future? The intelligent tourist who stands by the great cataract cannot allow the beauty, the grandeur, the vast magnificence of the scene, to bear down his imagination and bind up all his powers in the present. He looks and listens, and, while he stands overpowered by the falling torrent and rising spray, and thunderous pounding of torrent on fallen torrent, his imagination breaks the spell, and his thoughts wander away into the past and the yet to be. Are future ages to see this wonder, and find it as great as our eyes see it?

Mr. Hall, in his report on the Fourth District, and Sir Charles

FIG. 4.



MAP OF THE REGION OF NIAGARA FALLS.

1. Strawberry Island; 2. Beaver Island; 3. Tonawanda Island; 4. Cayuga Island; 5. Brockton Island; 6. Navy Island; 7. Goat Island; 8. American Fall; 9. Horseshoe Fall; 10. Gas Spring; 11. Oldest Terrace; 12. Whirlpool; 13. Preglacial Channel; 15, 15. Line of the Escarpment; N. New Suspension Bridge; O. Old Suspension Bridge; F. Fast Ground; 16, 17. Position of the Falls when the shale shall dip below the river-bed, and the limestone shall form the entire precipice. After receding so far, the Falls will then wear away into cascades and rapids. 18. The Old Barrier.

Lyell, in his "First Travels in the United States," have told us what they thought the Falls are coming to.

The reader will remember that the dip of the strata here is 20 feet a mile *southward*. He will remember, too, that the current below the Falls is 15 feet a mile northward. If he will turn to the section it may help him to see that a stratum which, a mile below the Falls, crops out along the bank 35 feet above the river, would be brought down, at the Falls, to the level of the river; and he will see that, for every mile the Falls have cut their way southward, they have lost 35 feet in height—the dip of the strata and slope of the channel. Let them cut back two miles farther (this is the reasoning of Hall and Lyell), and they will have passed the head of the Rapids. The shale which now lies at their base and forms the lower part of the precipice will have disappeared beneath the river-bed, and the limestone which has always been at the top of the precipice will have reached the bottom. As the Falls have receded by the action of the spray on the shale below, and the breaking and falling down of the undermined limestone above, now that the entire precipice is limestone, the features of the cataract will begin to change. The rock will wear away faster at the top than at the bottom, and the great Niagara—only a hundred feet high now—will dwindle away into a succession of cascades and rapids. This is the future as shaped in the minds of Hall and Lyell. They have overlooked an important fact—the change in the course of the river.

A reference to the map will show that the American Fall (8) is cutting eastward, and the Horseshoe (9) southward. But, after a few hundred feet have been cut away, the direction of the Horseshoe will change, and both Falls will move *eastward*. Above Goat Island they will unite and move on, one Fall, of immense width, till Navy Island cuts it in two. The greater Fall will then be on the American side, and its recession will still be eastward. A little Fall on the Canada side will retreat southward around Navy Island and then Grand Island. About a mile above the northern point of Grand Island this Fall will have moved southward far enough to leave the shale and have the precipice all of limestone. The water will then wear away the rim faster than the base, and the Fall will become a series of cascades and rapids.

But the main Fall will have to cut back to within a mile of Tonawanda Island—by the course of the river, nearly eight miles from the Horseshoe—before it makes the same southing. The Fall will have cut back, not *with* the dip, but nearly at right angles *across* it. And by the present rate of recession it must continue its work of excavation for 80,000 years before the shale will disappear under the bed of the river and the limestone form the entire precipice. Then the same fate will overtake this greater Fall which, ages before, awaited the other. All this on the assumption that Nature is to go on selecting her own channels and seeking her own ends.

But man is, here, greater as a mere dynamic than any other force acting on the globe. Already Niagara has felt his power. Fifty-two thousand cubic feet of water which belong to her, every summer minute he diverts to his own uses. Another century will see him on every acre along the borders of the upper lakes. Every forest he fells, every acre he ploughs, will affect, though inappreciably, the flow of water over the Falls. Time may come when his hand, laid on the earth in gigantic enterprise, will cause the Falls to shrink into insignificance. He will make these lakes furnish him highways to the ocean, east and south. A canal from Lake Michigan to the Illinois, great enough to float ships laden for the marts of Europe, and another from Lake Erie to Lake Ontario, are achievements in the near future.

YEAST.

By THOMAS H. HUXLEY, LL.D., F.R.S.

IT has been known, from time immemorial, that the sweet liquids which may be obtained by expressing the juices of the fruits and stems of various plants, or by steeping malted barley in hot water, or by mixing honey with water, are liable to undergo a series of very singular changes, if freely exposed to the air and left to themselves, in warm weather. However clear and pellucid the liquid may have been, when first prepared, however carefully it may have been freed from even the finest visible impurities, by straining and filtration, it will not remain clear. After a time it will become cloudy and turbid; little bubbles will be seen rising to the surface, and their abundance will increase until the liquid hisses as if it were simmering on the fire. By degrees, some of the solid particles which produce the turbidity of the liquid collect at its surface into a scum, which is blown up by the emerging air-bubbles into a thick, foamy froth. Another moiety sinks to the bottom, and accumulates as a muddy sediment, or "lees."

When this action has continued for a certain time, with more or less violence, it gradually moderates. The evolution of bubbles slackens, and finally comes to an end; scum and lees alike settle at the bottom, and the fluid is once more clear and transparent. But it has acquired properties of which no trace existed in the original liquid. Instead of being a mere sweet fluid, mainly composed of sugar and water, the sugar has more or less completely disappeared, and it has acquired that peculiar smell and taste which we call "spirituous." Instead of being devoid of any obvious effect upon the animal economy, it has become possessed of a very wonderful in-

fluence on the nervous system; so that in small doses it exhilarates, while in larger it stupefies, and may even destroy life.

Moreover, if the original fluid is put into a still, and heated for a while, the first and last product of its distillation is simple water; while, when the altered fluid is subjected to the same process, the matter which is first condensed in the receiver is found to be a clear, volatile substance, which is lighter than water, has a pungent taste and smell, possesses the intoxicating powers of the fluid in an eminent degree, and takes fire the moment it is brought in contact with a flame. The alchemists called this volatile liquid, which they obtained from wine, "spirits of wine," just as they called hydrochloric acid "spirits of salt," and as we, to this day, call refined turpentine "spirits of turpentine." As the "spiritus," or breath, of a man was thought to be the most refined and subtle part of him, the intelligent essence of man was also conceived as a sort of breath, or spirit; and, by analogy, the most refined essence of any thing was called its "spirit." And then it has come about that we use the same word for the soul of man and for a glass of gin.

At the present day, however, we even more commonly use another name for this peculiar liquid—namely, "alcohol," and its origin is not less singular. The Dutch physician, Van Helmont, lived in the latter part of the sixteenth and the beginning of the seventeenth century—in the transition period between alchemy and chemistry—and was rather more alchemist than chemist. Appended to his "Opera Omnia," published in 1707, there is a very needful "Clavis ad obscuriorum sensum referandum," in which the following passage occurs:

> Alcohol—In chemistry, a liquid or powder of extreme subtilty, from an Eastern word, *cohol* (or, better, *kohl*), used familiarly chiefly at Habessus, to denote an impalpable powder of antimony for painting the eyebrows. Alcohol is now used, by analogy, to express any very fine powder, such as powder for the eyebrows highly subtilized; and well-rectified spirits are said to be *alcoholized*.

Robert Boyle similarly speaks of a fine powder as "alcohol;" and so late as the middle of the last century the English lexicographer, Nathan Bailey, defines "alcohol" as "the pure substance of any thing separated from the more gross, a very fine and impalpable powder, or a very pure, well-rectified spirit." But, by the time of the publication of Lavoisier's "Traité Élémentaire de Chimie," in 1789, the term "alcohol," "alkohol," or "alkool" (for it is spelt in all three ways), which Van Helmont had applied primarily to a fine powder, and only secondarily to spirits of wine, had lost its primary meaning altogether; and, from the end of the last century until now, it has, I believe, been used exclusively as the denotation of spirits of wine, and bodies chemically allied to that substance.

The process which gives rise to alcohol in a saccharine fluid is known to us as "fermentation," a term based upon the apparent

boiling up or "effervescence" of the fermenting liquid, and of Latin origin.

Our Teutonic cousins call the same process "gähren," "gäsen," "göschen," and "gischen;" but, oddly enough, we do not seem to have retained their verb or substantive denoting the action itself, though we do use names identical with, or plainly derived from, theirs for the scum and lees. These are called, in Low German, "gäscht" and "gischt;" in Anglo-Saxon, "gest," "gist," and "yst," whence our "yeast." Again, in Low German and in Anglo-Saxon, there is another name for yeast, having the form "barm," or "beorm;" and in the midland counties "barm" is the name by which yeast is still best known. In High German, there is a third name for yeast, "hefe," which is not represented in English, so far as I know.

All these words are said by philólogers to be derived from roots expressive of the intestine motion of a fermenting substance. Thus "hefe" is derived from "heben," to raise; "barm" from "beren" or "bären," to bear up; "yeast," "yst," and "gist," have all to do with seething and foam, with "yeasty waves," and "gusty" breezes.

The same reference to the swelling up of the fermenting substance is seen in the Gallo-Latin terms "levure" and "leaven."

It is highly creditable to the ingenuity of our ancestors, that the peculiar property of fermented liquids, in virtue of which they "make glad the heart of man," seems to have been known in the remotest periods of which we have any record. All savages take to alcoholic fluids as if they were to the manner born. Our Vedic forefathers intoxicated themselves with the juice of the "soma;" Noah, by a not unnatural reaction against a superfluity of water, appears to have taken the earliest practicable opportunity of qualifying that which he was obliged to drink; and the ghosts of the ancient Egyptians were solaced by pictures of banquets in which the wine-cup passes around, graven on the walls of their tombs. A knowledge of the process of fermentation, therefore, was in all probability possessed by the prehistoric populations of the globe; and it must have become a matter of great interest even to primæval wine-bibbers to study the methods by which fermented liquids could be surely manufactured. No doubt, therefore, it was soon discovered that the most certain, as well as the most expeditious, way of making a sweet juice ferment was to add to it a little of the scum, or lees, of another fermenting juice. And it can hardly be questioned that this singular excitation of fermentation in one fluid, by a sort of infection, or inoculation, of a little ferment taken from some other fluid, together with the strange swelling, foaming, and hissing of the fermented substance, must have always attracted attention from the more thoughtful. Nevertheless, the commencement of the scientific analysis of the phenomena dates from a period not earlier than the first half of the seventeenth century.

At this time, Van Helmont made a first step, by pointing out that the peculiar hissing and bubbling of a fermented liquid are due, not to the evolution of common air (which he, as the inventor of the term "gas," calls "gas ventosum"), but to that of a peculiar kind of air such as is occasionally met with in caves, mines, and wells, and which he calls "gas sylvestre."

But a century elapsed before the nature of this "gas sylvestre," or, as it was afterward called, "fixed air," was clearly determined, and it was found to be identical with that deadly "choke-damp" by which the lives of those who descend into old wells, or mines, or brewers' vats, are sometimes suddenly ended; and with the poisonous aëriform fluid which is produced by the combustion of charcoal, and now goes by the name of carbonic-acid gas.

During the same time it gradually became clear that the presence of sugar was essential to the production of alcohol and the evolution of carbonic-acid gas, which are the two great and conspicuous products of fermentation. And finally, in 1787, the Italian chemist, Fabroni, made the capital discovery that the yeast-ferment, the presence of which is necessary to fermentation, is what he termed a "vegeto-animal" substance—or is a body which gives off ammoniacal salts when it is burned, and is, in other ways, similar to the gluten of plants and the albumen and casein of animals.

These discoveries prepared the way for the illustrious Frenchman, Lavoisier, who first approached the problem of fermentation with a complete conception of the nature of the work to be done. The words in which he expresses this conception, in the treatise on elementary chemistry, to which reference has already been made, mark the year 1789 as the commencement of a revolution of not less moment in the world of science than that which simultaneously burst over the political world, and soon engulfed Lavoisier himself in one of its mad eddies:

> We may lay it down as an incontestable axiom that, in all the operations of art and nature, nothing is created; an equal quantity of matter exists both before and after the experiment: the quality and quantity of the elements remain precisely the same, and nothing takes place beyond changes and modifications in the combinations of these elements. Upon this principle, the whole art of performing chemical experiments depends; we must always suppose an exact equality between the elements of the body examined and those of the product of its analyses.
>
> Hence, since from must of grapes we procure alcohol and carbonic acid, I have an undoubted right to suppose that must consists of carbonic acid and alcohol. From these premises we have two modes of ascertaining what passes during vinous fermentation: either by determining the nature of, and the elements which compose, the fermentable substances; or by accurately examining the products resulting from fermentation; and it is evident that the knowledge of either of these must lead to accurate conclusions concerning the nature and composition of the other. From these considerations, it became necessary accurately to determine the constituent elements of the fermentable substances;

and, for this purpose, I did not make use of the compound juices of fruits, the rigorous analysis of which is perhaps impossible, but made choice of sugar, which is easily analyzed, and the nature of which I have already explained. This substance is a true vegetable oxide, with two bases, composed of hydrogen and carbon, brought to the state of an oxide by means of a certain proportion of oxygen; and these three elements are combined in such a way that a very slight force is sufficient to destroy the equilibrium of their connection.

After giving the details of his analysis of sugar and of the products of fermentation, Lavoisier continues:

The effect of the vinous fermentation upon sugar is thus reduced to the mere separation of its elements into two portions: one part is oxygenated at the expense of the other, so as to form carbonic acid; while the other part, being disoxygenated in favor of the latter, is converted into the combustible substance called alkohol; therefore, if it were possible to reunite alkohol and carbonic acid together, we ought to form sugar.[1]

Thus Lavoisier thought he had demonstrated that the carbonic acid and the alcohol which are produced by the process of fermentation, are equal in weight to the sugar which disappears; but the application of the more refined methods of modern chemistry to the investigation of the products of fermentation by Pasteur, in 1860, proved that this is not exactly true, and that there is a deficit of from 5 to 7 per cent. of the sugar which is not covered by the alcohol and carbonic acid evolved. The greater part of this deficit is accounted for by the discovery of two substances, glycerine and succinic acid, of the existence of which Lavoisier was unaware, in the fermented liquid. But about 1½ per cent. still remains to be made good. According to Pasteur, it has been appropriated by the yeast, but the fact that such appropriation takes place cannot be said to be actually proved.

However this may be, there can be no doubt that the constituent elements of fully 98 per cent. of the sugar which has vanished during fermentation have simply undergone rearrangement; like the soldiers of a brigade, who at the word of command divide themselves into the independent regiments to which they belong. The brigade is sugar, the regiments are carbonic acid, succinic acid, alcohol, and glycerine.

From the time of Fabroni, onward, it has been admitted that the agent by which this surprising rearrangement of the particles of the sugar is effected is the yeast. But the first thoroughly conclusive evidence of the necessity of yeast for the fermentation of sugar was furnished by Appert, whose method of preserving perishable articles of food excited so much attention in France at the beginning of this century. Gay-Lussac, in his "Mémoire sur la Fermentation,"[2] alludes to Appert's method of preserving beer-wort unfermented for an indefinite

[1] "Elements of Chemistry." By M. Lavoisier. Translated by Robert Kerr. Second edition, 1793 (pp. 186–196).

[2] "Annales de Chimie," 1810.

time, by simply boiling the wort and closing the vessel in which the boiling fluid is contained, in such a way as thoroughly to exclude air; and he shows that, if a little yeast be introduced into such wort, after it is cooled, the wort at once begins to ferment, even though every precaution be taken to exclude air. And this statement has since received full confirmation from Pasteur.

On the other hand, Schwann, Schroeder and Dusch, and Pasteur, have amply proved that air may be allowed to have free access to beer-wort, without exciting fermentation, if only efficient precautions are taken to prevent the entry of particles of yeast along with the air.

Thus, the truth, that the fermentation of a simple solution of sugar in water depends upon the presence of yeast, rests upon an unassailable foundation; and the inquiry into the exact nature of the substance which possesses such a wonderful chemical influence becomes profoundly interesting.

The first step toward the solution of this problem was made two centuries ago by the patient and painstaking Dutch naturalist, Leeuwenhoek, who in the year 1680 wrote thus:

> I have frequently examined the ferment of beer, and always observed globules floating through the pellucid liquor; I also noticed very clearly that each single globule of the ferment gave origin to six other distinct globules, which, in size and form, I found, on careful observation, to correspond to the globules of our blood. But I conceived these globules to be due to and formed from the starchy particles of the wheat, barley, oats, etc., dissolved in and mixed with hot water; and in this water, which as it cools may be called beer, numerous minute particles joined together, and formed a globule, the sixth part of the compound globule, and thus the globules formed continuously in sixes."[1]

Thus Leeuwenhoek discovered that yeast consists of globules floating in a fluid; but he thought that they were merely the starchy particles of the grain from which the wort was made, rearranged. He discovered the fact that yeast has a definite structure, but not the meaning of the fact. A century and a half elapsed, and the investigation of yeast was recommenced almost simultaneously by Cagniard de la Tour, in France, and by Schwann and Kützing, in Germany. The French observer was the first to publish his results; and the subject received at his hands and at those of his colleague, the botanist Turpin, full and satisfactory investigation.

The main conclusions at which they arrived are these: The globular, or oval, corpuscles which float so thickly in the yeast as to make it muddy, though the largest are not more than $\frac{1}{2000}$ of an inch in diameter, and the smallest may measure less than $\frac{1}{7000}$ of an inch, are living organisms. They multiply with great rapidity, by giving off minute buds, which soon attain the size of their parent, and then either become detached or remain united, forming the compound glob-

[1] Leeuwenhoek, "Arcana Naturæ Detecta." Ed. Nov., 1721.

ules of which Leeuwenhoek speaks, though the constancy of their arrangement in sixes existed only in the worthy Dutchman's imagination.

It was very soon made out that these yeast organisms, to which Turpin gave the name of *Torula cerevisiæ*, were more nearly allied to the lower Fungi than to any thing else. Indeed, Turpin, and subsequently Berkeley and Hoffmann, believed that they had traced the development of the *Torula* into the well-known and very common mould —the *Penicillium glaucum*. Other observers have not succeeded in verifying these statements; and my own observations lead me to believe that, while the connection between *Torula* and the moulds is a very close one, it is of a different nature from that which has been supposed. I have never been able to trace the development of *Torula* into a true mould; but it is quite easy to prove that species of true mould, such as *Penicillium*, when sown in an appropriate nidus, such as a solution of tartrate of ammonia and yeast-ash, in water, with or without sugar, give rise to *Torulæ*, similar in all respects to *T. cerevisiæ*, except that they are, on the average, smaller. Moreover, Bail has observed the development of a *Torula* larger than *T. cerevisiæ*, from a *Mucor*, a mould allied to *Penicillium*.

It follows, therefore, that the *Torulæ*, or organisms of yeast, are veritable plants; and conclusive experiments have proved that the power which causes the rearrangement of the molecules of the sugar is intimately connected with the life and growth of the plant. In fact, whatever arrests the vital activity of the plant also prevents it from exciting fermentation.

Such being the facts with regard to the nature of yeast, and of the changes which it effects on sugar, how are they to be accounted for? Before modern chemistry had come into existence, Stahl, stumbling, with the stride of genius, upon the conception which lies at the bottom of all modern views of the process, put forward the notion that the ferment, being in a state of internal motion, communicated that motion to the sugar, and thus caused its resolution into new substances. And Lavoisier, as we have seen, adopts substantially the same view. But Fabroni, full of the then novel conception of acids and bases and double decompositions, propounded the hypothesis that sugar is an oxide with two bases and the ferment a carbonate with two bases; that the carbon of the ferment unites with the oxygen of the sugar, and gives rise to carbonic acid; while the sugar, uniting with the nitrogen of the ferment, produces a new substance analogous to opium. This is decomposed by distillation, and gives rise to alcohol. Next, in 1803, Thénard propounded an hypothesis which partakes somewhat of the nature of both Stahl's and Fabroni's views. "I do not believe with Lavoisier," he says, "that all the carbonic acid formed proceeds from the sugar. How, in that case, could we conceive the action of the ferment on it? I think that the first portions of the acid are due to a combination of the carbon of the ferment with the oxygen of the sugar,

and that it is by carrying off a portion of oxygen from the last that the ferment causes the fermentation to commence — the equilibrium between the principles of the sugar being disturbed, they combine afresh to form carbonic acid and alcohol."

The three views here before us may be familiarly exemplified by supposing the sugar to be a card-house. According to Stahl, the ferment is somebody who knocks the table, and shakes the card-house down; according to Fabroni, the ferment takes out some cards, but puts others in their places; according to Thénard, the ferment simply takes a card out of the bottom story, the result of which is that all the others fall.

As chemistry advanced, facts came to light which put a new face upon Stahl's hypothesis, and gave it a safer foundation than it previously possessed. The general nature of these phenomena may be thus stated: A body, A, without giving to or taking from another body, B, any material particles, causes B to decompose into other substances, C, D, E, the sum of the weights of which is equal to the weight of B, which decomposes.

Thus, bitter almonds contain two substances, amygdaline and synaptase, which can be extracted in a separate state, from the bitter almonds. The amygdaline thus obtained, if dissolved in water, undergoes no change; but, if a little synaptase is added to the solution, the amygdaline splits up into bitter-almond oil, prussic acid, and a kind of sugar.

A short time after Cagniard de la Tour discovered the yeast-plant, Liebig, struck with the similarity between this and other such processes and the fermentation of sugar, put forward the hypothesis that yeast contains a substance which acts upon sugar, as synaptase acts upon amygdaline; and as the synaptase is certainly neither organized nor alive, but a mere chemical substance, Liebig treated Cagniard de la Tour's discovery with no small contempt, and, from that time to the present, has steadily repudiated the notion that the decomposition of the sugar is in any sense the result of the vital activity of the *Torula*. But, though the notion that the *Torula* is a creature which eats sugar and excretes carbonic acid and alcohol, which is not unjustly ridiculed in the most surprising paper that ever made its appearance in a grave scientific journal,[1] may be untenable, the fact that the *Torulæ* are alive,

[1] "Das enträthselte Geheimniss der Geistigen Gährung (Vorläufige briefliche Mittheilung)" is the title of an anonymous contribution to Wöhler and Liebig's "Annalen der Pharmacie," for 1839, in which a somewhat Rabelaisian imaginary description of the organization of the "yeast animals," and of the manner in which their functions are performed, is given with a circumstantiality worthy of the author of "Gulliver's Travels." As a specimen of the writer's humor, his account of what happens when fermentation comes to an end may suffice: "When the animals find no longer any sugar, they devour one another; and this they do in a peculiar manner. They digest the entire animal, excepting only the eggs, which pass through the intestinal canal unchanged, and so the residuum is still a fermentable substance, viz., the sperm of the animals, which remains over."

and that yeast does not excite fermentation unless it contains living *Torulæ*, stands fast. Moreover, of late years, the essential participation of living organisms in fermentation other than the alcoholic, has been clearly made out by Pasteur and other chemists.

However, it may be asked, Is there any necessary opposition between the so-called "vital" and the strictly physico-chemical views of fermentation? It is quite possible that the living *Torula* may excite fermentation in sugar, because it constantly produces, as an essential part of its vital manifestations, some substance which acts upon the sugar, just as the synaptase acts upon the amygdaline. Or it may be that, without the formation of any such special substance, the physical condition of the living tissue of the yeast-plant is sufficient to effect that small disturbance of the equilibrium of the particles of the sugar which Lavoisier thought sufficient to effect its decomposition.

Platinum in a very fine state of division—known as platinum black, or *noir de platine*—has the very singular property of causing alcohol to change into acetic acid with great rapidity. The vinegar-plant, which is closely allied to the yeast-plant, has a similar effect upon dilute alcohol, causing it to absorb the oxygen of the air, and become converted into vinegar; and Liebig's eminent opponent, Pasteur, who has done so much for the theory and the practice of vinegar-making, himself suggests that, in this case—

> The cause of the physical phenomenon which accompanies the plant's life is to be attributed to a peculiar physical state, analogous to that of platinum black. It must, however, be observed that this physical state of the plant is closely connected with the plant's life.[1]

Now, if the vinegar-plant gives rise to the oxidation of alcohol, on account of its merely physical constitution, it is, at any rate, possible that the physical constitution of the yeast-plant may exert a decomposing influence on sugar.

But, without presuming to discuss a question which leads us into the very arcana of chemistry, the present state of speculation upon the *modus operandi* of the yeast-plant in producing fermentation is represented, on the one hand, by the Stahlian doctrine, supported by Liebig, according to which the atoms of the sugar are shaken into new combinations, either directly, by the *Torulæ*, or indirectly, by some substance formed by them; and, on the other hand, by the Thénardian doctrine, supported by Pasteur, according to which the yeast-plant assimilates part of the sugar, and, in so doing, disturbs the rest, and determines its resolution into the products of fermentation. Perhaps the two views are not so much opposed as they seem at first sight to be.

But the interest which attaches to the influence of the yeast-plants upon the medium in which they live and grow does not arise solely from its bearing upon the theory of fermentation. So long ago as

[1] "Études sur les Mycodermes," Comptes Rendus, liv., 1862.

1838, Turpin compared the *Torulæ* to the ultimate elements of the tissues of animals and plants. The elementary organs of their tissues, which might be compared to the minute vegetable growths found in common yeast, are likewise decomposers of those substances which environ them.

Almost at the same time, and, probably, equally guided by his study of yeast, Schwann was engaged in those remarkable investigations into the form and development of the ultimate structural elements of the tissues of animals, which led him to recognize their fundamental identity with the ultimate structural elements of vegetable organisms.

The yeast-plant is a mere sac, or "cell," containing a semifluid matter, and Schwann's microscopic analysis resolved all living organisms, in the long-run, into an aggregation of such sacs or cells, variously modified; and tended to show that all, whatever their ultimate complication, begin their existence in the condition of such simple cells.

In his famous "Mikroskopische Untersuchungen" Schwann speaks of *Torula* as a "cell," and, in a remarkable note to the passage in which he refers to the yeast-plant, Schwann says:

> I have been unable to avoid mentioning fermentation, because it is the most fully and exactly known operation of cells, and represents, in the simplest fashion, the process which is repeated by every cell of the living body.

In other words, Schwann conceives that every cell of the living body exerts an influence on the matter which surrounds and permeates it, analogous to that which a *Torula* exerts on the saccharine solution by which it is bathed—a wonderfully suggestive thought, opening up views of the nature of the chemical processes of the living body, which have hardly yet received all the development of which they are capable.

Kant defined the special peculiarity of the living body to be that the parts exist for the sake of the whole, and the whole for the sake of the parts. But when Turpin and Schwann resolved the living body into an aggregation of quasi-independent cells, each like a *Torula*, leading its own life and having its own laws of growth and development, the aggregation being dominated and kept working toward a definite end only by certain harmony among these units, or by the superaddition of a controlling apparatus, such as a nervous system, this conception ceased to be tenable. The cell lives for its own sake, as well as for the sake of the whole organism; and the cells, which float in the blood, live at its expense, and profoundly modify it, are almost as much independent organisms as the *Torulæ* which float in beer-wort.

Schwann burdened his enunciation of the "cell-theory" with two false suppositions: the one, that the structures he called "nucleus"

and "cell-wall" are essential to a cell; the other, that cells are usually formed independently of other cells; but, in 1839, it was a vast and clear gain to arrive at the conception that the vital functions of all the higher animals and plants are the resultant of the forces inherent in the innumerable minute cells of which they are composed, and that each of them is, itself, an equivalent of one of the lowest and simplest of independent living beings—the *Torula*.

From purely morphological investigations, Turpin and Schwann, as we have seen, arrived at the notion of the fundamental unity of structure of living beings. And, before long, the researches of the chemists gradually led up to the conception of the fundamental unity of their composition.

So far back as 1803, Thénard pointed out, in most distinct terms, the important fact that yeast contains a nitrogenous "animal" substance; and that such substance is contained in all ferments. Before him, Fabroni and Fourcroy speak of the "vegeto-animal" matter of yeast. In 1844, Mulder endeavored to demonstrate that a peculiar substance, which he called "proteine," was essentially characteristic of living matter.

In 1846, Payen writes:

> I recognize, in the numerous facts which have come under my observation, a law which has no exception, and which will lead us to regard vegetal life under a new aspect. If I am not mistaken, whatever we can discern under the form of cellules and vessels represents nothing but protective envelopes, reservoirs, and conduits, wherein the animated bodies which secrete and construct them find a home, food, and the means of transporting it, and where they throw off and reject excretory matter.

And again:

> To state fully the general fact, I repeat that bodies which discharge the functions performed by the tissues of plants, are formed of elements which, in slightly different proportion, make up animal organisms. Hence we are led to recognize a wonderful unity of elementary composition in all living bodies.[1]

In the year (1846) in which these remarkable passages were published, the eminent German botanist, Von Mohl, invented the word "protoplasm," as a name for one portion of those nitrogenous contents of the cells of living plants, the close chemical resemblance of which to the essential constituents of living animals is so strongly indicated by Payen. And through the twenty-five years that have passed, since the matter of life was first called protoplasm, a host of investigators, among whom Cohn, Max Schulze, and Kühe, must be named as leaders, have accumulated evidence, morphological, physiological, and chemical, in favor of that "wonderful unity of elementary composition in all living bodies," into which Payen had, so early, a clear insight.

[1] "Mém. sur les Développements des Végétaux," etc.—"Mém. Présentées," ix., 1846.

As far back as 1850, Cohn wrote, apparently without any knowledge of what Payen had said before him:

> The protoplasm of the botanist, and the contractile substance and sarcode of the zoologist must be, if not identical, yet in a high degree analogous substances. Hence, from this point of view, the difference between animals and plants consists in this, that, in the latter, the contractile substance, as a primordial utricle, is enclosed within an inert cellulose membrane, which permits it only to exhibit an internal motion, expressed by the phenomena of rotation and circulation, while in the former it is not so enclosed. The protoplasm in the form of the primordial utricle is, as it were, the animal element in the plant, but which is imprisoned and only becomes free in the animal; or, to strip off the metaphor which obscures the simple thought, the energy of organic vitality which is manifested in movement is especially exhibited by a nitrogenous contractile substance, which in plants is limited and fettered by an inert membrane, in animals not so.[1]

In 1868, thinking that an untechnical statement of the views current among the leaders of biological science might be interesting to the general public, I gave a lecture embodying them in Edinburgh. Those who have not made the mistake of attempting to approach biology, either by the high *a priori* road of mere philosophical speculation, or by the mere low *a posteriori* lane offered by the tube of a microscope, but have taken the trouble to become acquainted with well-ascertained facts, and with their history, will not need to be told that in what I had to say "as regards protoplasm," in my lecture "On the Physical Basis of Life," there was nothing new; and, as I hope, nothing that the present state of knowledge does not justify us in believing to be true. Under these circumstances, my surprise may be imagined, when I found that the mere statement of facts, and of views, long familiar to me as part of the common scientific property of Continental workers, raised a sort of storm in this country, not only by exciting the wrath of unscientific persons whose pet prejudices they seemed to touch, but by giving rise to quite superfluous explosions on the part of some who should have been better informed.

Dr. Stirling, for example, made my essay the subject of a special critical lecture,[2] which I have read with much interest, though, I confess, the meaning of much of it remains as dark to me as does the "Secret of Hegel" after Dr. Stirling's elaborate revelation of it. Dr. Stirling's method of dealing with the subject is peculiar. "Protoplasm" is a question of history, so far as it is a name; of fact, so far as it is a thing. Dr. Stirling has not taken the trouble to refer to the original authorities for his history, which is consequently a travesty; and still less has he concerned himself with looking at the facts, but contents himself with taking them also at second-hand. A most amusing example of this fashion of dealing with scientific statements is furnished by Dr. Stirling's remarks upon my account of the proto-

[1] Cohn, "Ueber Protococcus pluvialis," in the "Nova Acta" for 1850.

[2] Subsequently published under the title of "As regards Protoplasm."

plasm of the nettle-hair. That account was drawn up from careful and often-repeated observation of the facts. Dr. Stirling thinks he is offering a valid criticism, when he says that my valued friend Prof. Stricker gives a somewhat different statement about protoplasm. But why in the world did not this distinguished Hegelian look at a nettle-hair for himself, before venturing to speak about the matter at all? Why trouble himself about what either Stricker or I say, when any tyro can see the facts for himself, if he is provided with those not rare articles, a nettle and a microscope? But I suppose this would have been "*Aufklärung*"—a recurrence to the base, common-sense philosophy of the eighteenth century, which liked to see before it believed, and to understand before it criticised. Dr. Stirling winds up his paper with the following paragraph:

> In short, the whole position of Mr. Huxley, (1) that all organisms consist alike of the same life-matter, (2) which life-matter is, for its part, due only to chemistry, must be pronounced untenable—nor less untenable (3) the materialism he would found on it.

The paragraph contains three distinct assertions concerning my views, and just the same number of utter misrepresentations of them. That which I have numbered (1) turns on the ambiguity of the word "same," for a discussion of which I would refer Dr. Stirling to a great hero of "*Aufklärung*," Archbishop Whately; statement number (2) is, in my judgment, absurd; and certainly I have never said any thing resembling it; while, as to number (3), one great object of my essay was to show that what is called "materialism" has no sound philosophical basis!

As we have seen, the study of yeast has led investigators face to face with problems of immense interest in pure chemistry, and in animal and vegetable morphology. Its physiology is not less rich in subjects for inquiry. Take, for example, the singular fact that yeast will increase indefinitely when grown in the dark, in water containing only tartrate of ammonia, a small percentage of mineral salts, and sugar. Out of these materials the *Torulæ* will manufacture nitrogenous protoplasm, cellulose, and fatty matters, in any quantity, although they are wholly deprived of those rays of the sun, the influence of which is essential to the growth of ordinary plants. There has been a great deal of speculation lately, as to how the living organisms buried beneath two or three thousand fathoms of water, and therefore in all probability almost deprived of light, live. If any of them possess the same powers as yeast (and the same capacity for living without light is exhibited by some other fungi), there would seem to be no difficulty about the matter.

Of the pathological bearings of the study of yeast, and other such organisms, I have spoken elsewhere. It is certain that, in some animals, devastating epidemics are caused by fungi of low order—similar

to those of which *Torula* is a sort of offshoot. It is certain that such diseases are propagated by contagion and infection, in just the same way as ordinary contagious and infectious diseases are propagated. Of course, it does not follow from this, that all contagious and infectious diseases are caused by organisms of as definite and independent a character as the *Torula;* but, I think, it does follow that it is prudent and wise to satisfy one's self in each particular case, that the "germ-theory" cannot and will not explain the facts, before having recourse to hypotheses which have no equal support from analogy.—*Contemporary Review.*

MEASUREMENT OF EARTHQUAKE-WAVES.

By GEORGE FORBES.

WHILE the scientific world and his own countrymen are rivals in doing honor to Prof. Palmieri for his zeal in remaining at his post in spite of all danger, it may be interesting to examine in some detail the work done at the Observatory of Mount Vesuvius. We know wonderfully little about the origin and mutual dependence of volcanic phenomena. This is due to a want of accurate observations. For the complete investigation we require first to know at what dates earthquakes and eruptions occur at different parts of the earth. Next we must have observations of the direction and exact hour at which a wave of disturbance passes different places whose positions are known. This gives us the velocity of the wave, and helps to determine the position, under the earth's surface, of the centre of disturbance; or, if a wave be propagated over the sea, we obtain a means of estimating the average depth of the intervening ocean; for the velocity of a wave increases with the depth of the sea. This method gives one of the best determinations we possess of the depth of the Pacific Ocean. But beyond this we must have observations made systematically at some place subject to earthquakes and volcanic eruptions. No place in Europe is more suitable for this than the neighborhood of Mount Vesuvius; and it was for such observations that an observatory was established there.

Every one knows that Mount Vesuvius consists of a vast cone of lava and ashes, at the top of which is the great crater. On the northern side, separated from it by the deep valley called the Atrio del Cavallo, rises the precipitous and semicircular Monte Somma. This once formed the crater of the volcano, and the present cone seems to have been formed inside that great crater at the time when Pompeii was overwhelmed. On a spur of rock, a mile or two in length, running down from the Atrio del Cavallo, the Observatory is placed. It is

close to the well-known "Hermitage," or half-way house, in the ascent of the mountain. Being raised on this ridge above the surrounding country, it is comparatively safe from the molten lava that flows at times on either side of it.

The building itself is handsome; in fact, it is to be regretted that so much money should have been devoted to the masonry instead of to additional instruments. On the ground-floor are the inhabited rooms, all scantily furnished; but the pursuers of science cannot always expect bodily comfort. On the first floor we find the Museum, with a fine collection of minerals found on the mountain. Perhaps it may be as well here to correct the common mistake as to the nature of the yellow substance found about the craters, whose brilliant colors remind one so much of the Solfatara. This substance is not sulphur, but copper. The most interesting objects in the Museum are the "fumerolles," or smoke-holes. Occasionally at the end of an eruption you may see at the bottom of the crater a small cone of lava, with a hole in its top, through which the steam pours with a hissing noise like a wave breaking on a pebbly beach, or like a blast-furnace, or, as Pliny has it, like the grinding of a saw; the intensity of the sound varying with your position. These small cones are the fumerolles; they are a foot or two high; and Palmieri has actually had several of these natural chimneys cut off and transported to the Museum.

We now pass on to the Observing-Room. There are solid piers carried up from the ground to support the instruments. First comes the elegant *seismograph*, an instrument for the automatic registration of earthquake-shocks. The object of the instrument is twofold: first, to measure the direction and intensity of a shock; and, second, to write down a history of the earthquake. The shock may be either vertical or horizontal, or partly vertical and partly horizontal. For the vertical shocks a fine metallic point is suspended by a coil of wire over a cup of mercury. The coil of wire acts as a spring, and the slightest upward motion of the earth is sufficient to cause the point to dip into the cup of mercury. This completes a galvanic circuit, which stops a clock at the exact half-second at which the shock occurred, and rings a bell to call the observer, and also does other work which we shall speak of again. There are three or four helices of wire of different strengths, which support small magnets above a cup of iron filings. When a vertical shock occurs, some of these magnets dip into the iron filings. To one of these a light index is attached, for measuring the intensity of the shock.

For horizontal shocks there are four glass tubes. Each of them is bent twice at right angles, so as to form a U-tube. One arm of this tube has more than double the diameter of the other, and is shorter. The four tubes point in the directions of the four cardinal points. Each tube has a certain quantity of mercury poured into it, and on the surface of the mercury, within the narrow arm of the tube, there rests

a small weight attached to a silk fibre, which passes over a delicate ivory pulley, and has a counterpoise attached at the other end. Each pulley has an index and circular scale to mark the angle turned through. The extremity of a wire is fixed at a small distance above the surface of the mercury in each tube. If, then, a horizontal shock occur, the mercury rises in the corresponding tube; but it rises higher in that one which has its long arm to the north. The pulley is turned through a certain angle, which is measured by the index, and at the same time the mercury in rising comes in contact with the fixed wire, and so completes a galvanic circuit which rings a bell, and stops the clock at the exact half-second when the shock occurred. If the shock comes from some intermediate point, two of the indices will be moved, and the direction and intensity can be measured by observing both of them. We have seen up to this point that the instrument will measure the direction and intensity of a shock, will mark the time at which the shock occurred, and will ring a bell to attract the attention of the observer on duty, who may register succeeding shocks, or, if the earthquake has ceased, may reset the apparatus. But this is not all. The galvanic circuit, which is completed at the moment a shock occurs, releases at the same instant the pendulum of a second clock, which has been held out of the vertical by means of a detent. This clock allows a roll of paper to be unwound off a drum, as in any registering telegraph, at the rate of three metres an hour. A pencil rests nearly in contact with the strip of paper. It is connected with one arm of a lever, the other arm of which is slightly distant from an electro-magnet. As often as the current passes, this end of the lever is attracted to the magnet, and the pencil in consequence is made to press on the paper, to be released only when the current ceases. By this means, then, a continuous history of the earth's trembling is registered, a pencil-mark corresponding to a time of trembling, and a blank space to a period of cessation.

This instrument is extremely delicate, and registers motions of the earth which are too slight to be perceptible to the human frame. When we examined it, some one happened accidentally to touch the casing of the instrument. The alarm was immediately given by the bell, and the two clocks were respectively checked and put in motion by the galvanic current.

In the same room there is apparatus for detecting and measuring atmospheric electricity. A gold-leaf electroscope and a bifilar electrometer are observed regularly. These are successively put in connection with the conductor. This consists of a disk of metal above the roof of the house connected with an insulated metallic rod, supported vertically, and capable of being rapidly raised by means of a cord passing over a pulley. When not in use this rod is in connection with the ground. In making an observation, the rod with the disk attached is quickly raised, thereby disconnecting it from the ground. The elec-

tricity of the atmosphere at the point where the disk is fixed affects the electroscope and electrometer. Prof. Palmieri prefers the conductor above described, to a conducting point or a flame, because he considers that these do not give comparable results, an objection which is not supported by all observers. He considers the same to be true of the method of dropping water.

After having made careful observations on atmospheric electricity for about a quarter of a century in a country where meteorological changes are more regular and less capricious than in our own island, there is no one whose deductions are more deserving of our attention; the more so as he considers that he has combined his researches into a definite law. His first fact is this: *If within a distance of about fifty miles there is no shower of rain, hail, or snow, the electricity is always positive.* The single exception is during the projection of ashes from the crater of Vesuvius. During a shower he finds the following law universally to hold good: At the place of the shower there is a strong development of positive electricity; round this there is a zone of negative, and beyond this again positive. The nature of the electricity observed depends upon the position of the observer with respect to the shower, and the phenomena will change according to the direction in which the shower is moving. Sometimes negative electricity may be observed during a shower; but this is always due to a more powerful shower farther off. These conclusions have been supported by means of telegraphic communication with neighboring districts. It appears, then, that except when the moisture of the air is being condensed, there is no unusual development of electricity. These results are in accordance with the experiments of Palmieri and others, which show that aqueous vapor in condensing develops positive electricity. No unusual development of electricity has ever been detected by him in a cloud when no rain is falling.

The above results, though falling short of what has to be done to complete the theory, are yet definite, and hence valuable, the more so if supported by other observers placed in equally favorable situations. But of the variations *in intensity* of positive or negative electricity nothing has been said.

Besides the fixed instruments at the Observatory, others are used on the mountain. Gases are collected from cracks in the earth's crust, tubes being let down into them, and the gas sucked up by a kind of bellows, to be examined at leisure. A portable spectroscope is also used during eruptions, and there is a larger one by Hoffman in the Observatory. From this Observatory we have received valuable information, and it is much to be regretted that equally efficient observatories have not been established in different parts of the world. Many portable and cheap instruments have been invented, most of which are described by Mr. Mallet, in the "Admiralty Manual of Scientific Inquiry;" but there ought to be three or four as delicate as

that on Mount Vesuvius. It is a pity that no observatory has ever replaced the ancient one of Empedocles, near the summit of Etna, or even at Nicolosi, where the valuable services of Dr. Gemellaro might have been obtained. This would have been the more interesting, as Palmieri can detect shocks caused by that volcano, though the distance is enormous. With a third observatory, say in the Philippine Islands, we could not fail to increase our knowledge enormously.

From long practice Palmieri is able to predict eruptions. We remember well, when we were enjoying his hospitality at the beginning of last year, how he said, "This is a small eruption, but there is going to be a great one; I do not say it will be soon, it may be a year, but it will come." In almost exactly a year the great eruption did come. —*Abstract from Nature.*

SCHOOL DIETARIES.

By M. D.

IN the neighborhood of one of our midland cities is a school for some fifty boys, varying in age from nine or ten to fourteen or fifteen years. During some recent visits to this school, the singular healthiness and heartiness of the boys made me curious to learn exactly how they were fed. The following I ascertained to be the dietary:

Breakfast (in summer at 8, in winter at 8.30) consists of tea or good strong coffee, with abundance of milk, bread-and-butter, and cold meat. By way of change, now and then, eggs for a few days together take the place of meat. Before the foregoing, boys who like it have a small basin of bread-and-milk, or of Scotch porridge made with milk. The milk is new, and comes straight from a farm adjoining the school-grounds.

Lunch at 11.—Each boy has a small fresh roll of bread, or a bun, or a captain's biscuit, and, if weakly, a tumbler of milk or small glass of wine or ale; but, as a rule, nothing is drunk at lunch, dinner, or supper, but pure water.

Dinner, at 1.30, always consists of two courses: 1. Two kinds of meat, viz., beef and mutton, with not less than two kinds of vegetables, and of these a liberal supply. 2. Pudding, usually of fruit, fresh or preserved according to the season, and always well sweetened. On four days of the week the meat is hot roast; on one day it is hot boiled; on one day steaks, cutlets, or made dishes, are substituted for joints; while the Sunday dinner always consists of cold beef, mashed potatoes or salad, and plum-pudding. After dinner some ripe fruit, as an orange or some kind of garden-fruit, according to the season.

Tea at 6 P. M.—Tea, bread-and-butter, varied almost daily either

with home-made plum-cake, or marmalade or honey. Whenever procurable, some salad-herb, such as lettuce, radish, etc., is given at this meal, and always eaten with much relish.

Supper at 8 P. M. (for senior boys only).—Bread-and-butter, or bread-and-cheese, or biscuit, or, where it may seem needed, a tumbler of milk, or glass of beer and a meat sandwich.

No hampers of eatables are allowed to be sent to the boys from their friends, and no shop for the sale of sweets, etc., is allowed or accessible to the boys.

This dietary seems to me so exactly what growing boys or girls ought to have, and so often what they do not get, even at their own homes, that it may appropriately serve as the text for a few remarks on the usual dietaries of public and private schools. I will begin by at once stating my belief—as one who was himself at a private and a public school, and who still sees a good deal of school-boys—that either in quality, quantity, variety, or frequency of meals, the dietary of nearly every school I have known is more or less defective.

The usually unvaried breakfast of tea or coffee (and these fluids too often of a miserably thin description), with bread-and-butter, is a meagre meal for a boy who has to break a twelve-hours' fast. It is not enough for the robust, nor varied enough for the delicate. A good basin of bread-and-milk, or milk-porridge, should always be allowed as a substitute for tea or coffee; and the latter, when preferred, should always be accompanied with some little extra, such as a bit of cold meat, or bacon, or an egg—sometimes one, sometimes the other, so as to secure the utmost possible variety. Coffee, by-the-way, should be of good quality, strong enough to require copious dilution with milk, and not the sloppy decoction of brown paper which it too often resembles in taste, appearance, and nutritive value.

Nearly all boys want something between breakfast and dinner, about 11 o'clock; and if this something be not provided for them in a wholesome form by the school-master, they will seek to get it, probably in a much less wholesome form, at the school "shop," or in the contents of the "hamper from home." Concerning these two venerable institutions more shall be said presently.

Meat or other food of bad quality is hardly ever put on the table nowadays in any decent school. Equally rare is any stint in its allowance. The fault of most school dinners is roughness in the cooking and serving, insufficient variety in the form and kind of meat and vegetables, and the too frequent absence of puddings. It will be seen by the above dietary that, with very little strain of culinary arrangements, meat may be served up in half a dozen different forms each week, and, if two kinds of it always come to table, ample variety will have been attained. Variety in food is no mere luxury or pampering of appetite. In all cases desirable, in the case of growing boys it is highly so; while in the case of boys with delicate or capricious appe-

tites it becomes an absolute necessity. A certain percentage of such boys will be found in every school—boys who, if denied considerable range of choice in their food, will at least fail to thrive in the midst of plenty.

A boy's chief meal should always consist of two courses, meat and pudding.[1] Many boys, being small meat-eaters, should at least have the chance of "making up" with something further, and good reason can be given why this something should be a well-sweetened pudding or tart; if containing fresh or preserved fruit, so much the better. All boys as a rule dislike meat fat and leave it on their plates, and it is a barbarous practice to try to make them eat it.[2] And yet the same fat in a different guise, embodied with flour in a *well-cooked* pudding, they as universally like. All boys, again, love sugar and the juices of fresh vegetables or fruits, and it is a grave mistake not to secure a fair proportion of these elements in their daily food. Now, a well-made fruit-pudding or tart combines these several elements in happy proportion and palatable form; and boys' universal liking for this article of diet is simply the practical expression of the physiological truth that fat and its chemical allies, starch and sugar, together with certain organic acids and salts, are indispensable to the healthy constitution of the blood; in other words, to the due building up and maintenance of the fabric of the body.

A boy who has dined at 1 or 1.30 is ready by 6 o'clock for something more than the eternal tea and bread-and-butter. He keenly relishes at this meal some little variety or addition, such as plain home-made cake, or some preserve, or a bit of whatever salad-herb may be in season. The dietetic value of salad-herbs (lettuce, water-cress, etc.) to growing boys is out of all proportion to their cost. Where there is a kitchen-garden (which every school should have), they practically cost nothing. Where they have to be bought, they need not cost much; and, even if they do, they will be worth the price.

Should boys have supper? Up to about twelve years of age they rarely need it, for boys of this age by 9 o'clock are ready for bed, and should be in bed; but from thirteen or fourteen onward boys much dislike being sent to bed so early, and if they do, say, one and a half or two hours' work after tea, they feel the want of, and ought to have, a light meal between 8 and 9 o'clock.

In the dietary above quoted it will probably excite surprise that no beer or other stimulant is allowed either at dinner or at any other meal or time in the day, except in special cases where a boy's health is

[1] Boys seldom care for *soup*.

[2] I was myself at a private school—an average good one in its day—where the rule was enforced that on "pudding-days" no boy who had left any fat on his plate should have any pudding. After a while meat rose in price, and, by way of "choking us off," we were made on these said days to eat the pudding before the meat. This was blundering strategy on the master's part, for he had now no hold upon us, and the meat was of course eaten without any fat at all.

thought to require such aid. If proof were needed that boys *may* grow up in the perfection of health and strength without any stimulants whatever, *provided they are liberally fed*, I might point to the splendid *physique* of the little inmates of this particular school, and invite any one to see how they work and how they play. Where the food is amply sufficient and varied, a boy does not want beer, nay, is better without it; where the food is not so, beer or wine will but imperfectly supplement its shortcomings. With delicate or sickly boys, of course the case is different; they have special needs in respect of stimulants which it would be foolish to ignore.

Another noteworthy point in the arrangements of this school is the veto on all "hampers from home," and the absence of any "shop" for the sale of sweets, etc. These are far from harmless institutions; they are time-honored abominations which cannot be too strongly condemned. The evil tendencies, at any rate of the latter, are so glaring that its authorized existence is, in my opinion, a blot upon any school. Setting aside the trash eaten, the sickness caused, the morbid appetite and habit of selfish gluttony acquired, and the facilities afforded for the introduction of contraband goods—the money boys often spend at these places is grievous to think of. I can vouch for many a boy, whose parents were weak enough to supply him with almost unlimited pocket-money, having often spent at his school "shop" a weekly sum quite sufficient to feed a poor family. Now, where school-meals are abundant enough, varied enough (especially in respect of sugar, starch, and vegetable juices), and frequent enough, there the inmates will have no further craving for cakes, sweets, fruits, etc. But if there be a shortcoming in one or other of these respects, then instinct drives the boys to seek elsewhere those elements of food in which their regular diet is deficient. An authorized "tuck-shop," therefore, in connection with a school, is *prima-facie* evidence to an outsider, and not uncommonly a tacit admission on the part of the school-proprietor, that the diet of the inmates by no means satisfies all their legitimate cravings.

That a scale of diet such as I have here advocated is just about what boys ought to have—*if they are to develop into strong, healthy men*—I am satisfied from personal experience and observation. That it is at all likely to meet with the acceptance of school-masters generally, I am not simple enough to suppose. It is too violent an innovation on old routine. Nay, even *paterfamilias* himself will probably pooh-pooh such new-fangled notions of feeding boys like grown men (especially when he finds they cost more money), forgetting that boys need more and more varied food than men. So-and-so was good enough for his (*pater's*) boyhood, why won't it do for his son's? But *paterfamilias* should speak only for himself. The diet of *his* school-days sufficed for *him*, thanks probably to his sound constitution, but was it enough for many of his less robust schoolmates? Did any of

these in after-years fail to grow up strong and healthy men? and, if so, is *paterfamilias* sure that their "simple," i. e., monotonous and meagre mode of feeding during their years of most active growth had naught to do with their failure?

Just as any system of teaching is a real success in proportion as it adapts itself to the peculiar needs—not of those who are quick and willing, but of those who are slow or averse to learn—so any scale of diet approaches perfection in exact proportion to the provision made, not merely for the average standard of taste and appetite, but for all reasonable deviations therefrom. The daily meals of a school may be abundant and of good quality, still, if they be not more varied than to my certain knowledge they often are, many a boy and girl must fail day after day to get those particular elements of nutrition which they specially require. The result with such boys and girls is that even in the midst of plenty they remain permanently underfed and imperfectly nourished, thus retarding, if not arresting, the due growth and development of their bodies, and strongly favoring the development of any inherited or other constitutional unsoundness lurking within them. —*Food Journal.*

SCIENTIFIC DABBLERS.

By F. W. CLARKE.

THERE is, perhaps, no more amusing trait in human nature than that which leads people to criticise subjects about which they know nothing. And it seems to be a trait common to all minds, but differing much in intensity. Education roots it out to a considerable extent, but never quite obliterates it. The more ignorant the critic, the more confident are his assertions.

Four departments of knowledge are especially infested by these critical parasites, namely: physical science, metaphysics, politics, and theology. Persons wholly ignorant of political economy discuss taxation, capital, the rights of property, and similar questions, in the most solemn and owl-like manner; others, who know so little of natural history as to be almost unable to tell a grasshopper from a gorilla, will point out Darwin's errors most lucidly; and men who have the vaguest ideas as to the meanings of the polysyllables which they habitually use, expound, with wonderful clearness, the nature of infinity, and invent new theories of the universe for every day in the week.

At the present time, natural science is a favorite field for the gambols of these wiseacres. And, strange as it would seem, at first sight, their energies are usually directed to the highest and most difficult subjects. The sciolist rarely wastes his thoughts upon simple matters. And

plainly, since he is ignorant of that which he expounds, it is better for him to leave common things to common minds, and, by discussing the loftier questions of the day, get greater credit for wisdom from those who are equally ignorant with himself. He is safer from overthrow in speculating upon unsettled theories than in attempting to explain that which has been well demonstrated.

Probably the majority of Americans get their ideas upon scientific questions from the newspaper and the pulpit. The meagre quantities of scientific lore picked up in the common schools, and in most of the colleges, are scarcely important enough to be worth noticing; and the knowledge doled out in the form of popular lectures is so often beaten up into froth, to suit the tastes of those who listen merely to kill time, that it may also be left out of question. But, week after week, the clergy hurl forth their anathemas against the profanities of science, and, day after day, the newspapers quote the sayings of the popular reviews. And but too frequently clergymen and journalists are both mere scientific dabblers. Not always, but wofully often. Quite naturally, then, much of the information given is practically worthless. The really important discoveries are rarely noticed until they are years old, for these retailers of scientific gossip scarcely ever know what is of value, and generally content themselves with giving remarkable theories, broached by intellectual quacks, or brilliant illustrations of principles, with the principles themselves left out. The surface is given, but the meanings lying beneath are neglected.

Now and then, however, a startling theory is put forward by some eminent scientist, or, after lying comparatively unnoticed for years, is lifted into sudden prominence. And, presto! down sweep the clergy upon it as opposed to religion; and the newspapers, roused by the noise, add their dubious ridicule to the forces of the Church. Only the press is generally less conservative than the pulpit. Its attacks are not nearly so virulent as those of the theologian.

And unquestionably these assaults do some good. They advertise the theory, set people to thinking, and, in some measure, stimulate the advance of the truth. Had it not been for Romish persecution, Galileo's views might have been much slower in gaining ground; and it is likely that, if the English pulpit had made less vigorous attack upon young Geology, there might still have been educated men believing in the literal six days' creation and the universal deluge. And yet it is worth noticing, in this connection, that a book has been published in England, within the past two years, which is meant to show that the earth is not a globe, and that the sun revolves around it. The author's chief arguments are that "water is level," and that his views are scriptural. He calls Newton a "lunatic" (these are the words of his prospectus), and the Astronomical Society a set of "professional liars." Equally ridiculous statements upon scientific matters may be heard from popular lecturers and writers nearly every day.

As I have already stated, the scientific dabbler prefers to disport himself in the field of theory. And, at present, there are several great questions up for discussion before the scientific world. The most prominent among them relate to the connection between vital and physical forces, the origin of life, the development of species, and the antiquity of man. In general, the pulpit has in the most Christian manner allied itself *with the weaker side.* In many instances, the press follows the lead of the priesthood. And on each question there seems to be popular misunderstanding.

The first of these questions is practically settled. Experiment has thrown much light upon it, and now the leaders in science are pretty well agreed that the ordinary forces of Nature are sufficient to produce all the physical phenomena of life. And yet, when a well-known chemist, a year or two ago, stated, before a New York audience, the simple fact that the animal heat is the result of purely physical actions in the system, an astute letter-writer took him roundly to task for his "absurdities," and actually found a newspaper to print the effusion. The lecturer stated an experimental fact, while the objector merely vented ignorant prejudice. If a man who had never learned to read should attempt to instruct an experienced printer in the art of setting type, he would hardly present a more ridiculous spectacle than this self-appointed critic.

In discussing the origin of life, we find the theory of spontaneous generation brought prominently forward. Certain experimenters have enclosed various substances in hermetically-sealed tubes, heated them, so as to apparently destroy all possibilities of life within, and, after allowing them to remain undisturbed for months, have found the contents swarming with animalcules. Other scientists have tried similar experiments under varied circumstances, and have failed to obtain living organisms. And no one but a man trained in scientific methods can judge of the relative values of the experiments. Yet many clergymen do not hesitate to decide at once in favor of the negative experiments, in spite of the fact that no thorough scientist regards the questions involved as in any degree settled. The leading opponents of spontaneous generation seem to oppose the doctrine only provisionally, on the ground that the evidence accumulated is not sufficient to warrant a final decision. The weight of evidence, however, seems to lend probability to the doctrine. The successes of Wyman, Bastian, and others, more than counterbalance all failures. Yet more exact experiments are needed. It is plain that the first life must have been developed from non-living matter, whatever methods the Creator may have employed. Why may not the same methods be acting to-day? The clerical opponents of the theory here fall into an obvious error. They impute to it tendencies which it cannot have. The question to-day is, not whether life arose by a Divine act, but, in what manner did it arise? If it should be proved that living beings may be produced by natural laws

from non-living matter, it will merely be shown that they arose in accordance with the universal design. That is, looking from the standpoint of a belief in Deity, it would be demonstrated that here, as throughout all the domain of Nature, His work was done systematically, through the medium of law, and not in an arbitrary, mechanical, dust-moulding manner. And no one can find any thing atheistic, or even materialistic, in such a view. The question is one of visible order *versus* seeming disorder, the probabilities being in favor of the former.

Not long since, Darwin's "Descent of Man" was published. And shortly afterward, I stumbled upon a newspaper review, which was made up of unreasoning ridicule. The writer was evidently no specialist in science, and yet he ventured to discuss a theory propounded by one of the most thorough naturalists living, who is supported in his views by probably a large majority of scientific men. And the most astonishing portion of this astonishing review was, where the writer asserted that the book did not contain a single argument which would convince any one but a scientific man! As if any one but a scientific man was able to judge fully of the merits of the arguments.

Now, space forbids my entering into discussion of the development-theory (which, by-the-way, did not originate with Darwin, his being merely one of several development-theories), and yet a word or two is necessary. The naturalist, looking about him, sees many facts which require to be classified and explained. He sees that all mammals resemble each other anatomically; he finds evidences of development from lower to higher stages in their embryos; he is confronted by the fact that species are modified by cultivation; and he meets with hosts of observations chiming in with these. The development-theory is naturally suggested to his mind. Flinging prejudices to one side, he finds that the theory classifies many of these facts, and renders them mutually intelligible. To be sure, the doctrine is not absolutely proved, but then there are all these things in its favor, and little more than negative evidence against it. He has learned to beware of negative evidence, however, as often leading to fallacies; and, looking at all the difficulties in the way, accepts the theory, provisionally at least, as superior to any other which has been suggested. It may not be true, or it may; at all events it classifies his knowledge for him, and is useful for the time being. And he finds that, instead of giving him degraded views of man, it enables him to see both God and humanity in clearer light. The progress indicated in the past hints at greater progress in the future, and encourages him to stronger and better efforts. Development is shown to be a part of man's duty, and the hope of success is strengthened.

The question of the actual antiquity of man will probably never be settled. If man, as the development-theory holds, arose by the slow modification of lower species, then it is plain that no precise moment

can be pointed out in which he ceased to be brute and became human. But in some senses the question of antiquity may be answered. It may be proved that man, as we now recognize him, has existed on earth *more* than a certain number of years. That period may be of six, ten, twenty, or a hundred thousand years; how *much* more we may never know. And the quarrels upon the subject to-day are over the accuracy of the Mosaic estimate of 6,000 years. The question has been discussed on both sides by clerical dabblers. On the one hand, I have heard an eminent "evangelical" divine assert most dogmatically that there was absolutely no evidence to overthrow the Mosaic chronology, and that all belief to the contrary was "utter delusion." On the other side, I have listened to a prominent "liberal" preacher who claimed that it was almost certain that man had dwelt on the earth for at least 4,000 centuries! And probably neither of those estimable men had a very clear conception of the subject they discussed so airily. Not only does space forbid my entering at length into this subject, but, if I should do so, I should lay myself open to the charge of being a scientific dabbler. Suffice it to say that the best scientific authorities appear to be well agreed that man has existed for much more than 6,000 years. Human bones have been found under circumstances which make it highly probable that they were buried at least 20,000 years ago. There was not, perhaps, absolute proof, but probability. And this probability, supported as it is by some evidence, is far more worthy of belief than the mere unfortified assertions of the Old Testament. Whatever value the latter work may have in its relations to morality and religion, it is an unsafe guide in matters of science. Geology and astronomy have both contended with it, and have come off victorious. Perhaps its errors may exist only in the interpretations of theologians; if so, the interpreters may be deceived even now.

I do not wish to be understood as attacking the clergy. I wish only to show that science will not bear to be used for partisan purposes. The truth must not be tampered with. And clergymen, in dealing with science, are often mere special pleaders, who wilfully ignore much evidence. There are some preachers who are controversially inclined, and batter away at science whenever it crosses their path. And they often stultify themselves. For instance, they attack the Darwinian theory, and reject it because it is not proved. But they accept the theory of individual creations, which is equally unproved. It would be wiser for them to hold judgment in suspense, and wait for the decisions of competent investigators. But here some reverend gentleman may say indignantly: "What! shall we not defend our faith against the attacks of science?" Certainly, my dear sir; only do not be careless. First make sure that your faith is attacked; then, that you understand the nature of the attack, and then give your opponent credit for honesty equal with your own. Do not hesitate to look squarely at all the evidence bearing upon the questions in-

volved; defend yourself with arguments, not dogmatic assertions; and do not ask your adversaries for proofs stronger than those which you are ready to give. Above all, remember that you yourself are but mortal, and liable to err; and therefore that it is always within the bounds of possibility that your antagonist may be in the right, and you in the wrong. The man of science studies God's own handiwork; he approaches the truth reverently, yet fearlessly, seeking it for its own sake; and his conclusions cannot be lightly disregarded. Science may throw more light upon theology than theology can ever throw upon science. And the theologian who sincerely wishes to know and to spread the highest and clearest truths, will do well to take at least some lessons from the interpreters of Nature, and in all cases to treat the doctrines of science with the respect which is always due to honesty. Under all circumstances, whatever may be his private views and his desires, he will find it the part of wisdom not to commit himself publicly to either side of an unsettled question. Dogmatism on undecided points is worse than foolish.

Every now and then we meet with certain scientific dabblers who are silly through the medium of the newspapers. I refer to those unfortunate people who try to illustrate science with fanciful statistics. Of late, one of these statistical paragraphs has been going the rounds of the press. It treats of what the writer supposed to be physiological chemistry. First come some estimates as to the number of pairs of boots and the quantity of hats which might be made from the leather and felt imagined by the author to be formed by some obscure chemical process in the stomach. This is utilitarian science with a vengeance, but is eclipsed shortly when the brilliant popularizer of scientific knowledge asserts that a man of average size contains clay enough to make a dozen large bricks, and consumes carbonate of lime enough with his food to form a marble mantel-piece in a year! The estimates are really quite beautiful in their way, but are unfortunately like the French definition of a crab. Certain French lexicographers were one day hard at work, and had just defined a crab as "a little red fish which walks backward." Cuvier, entering just then, was asked what he thought of the definition. "Admirable!" said he, "only the crab is not a fish, it is not red, and it does not walk backward." I cannot vouch for the authenticity of this anecdote, yet it serves very well to illustrate the case in point. The newspaper scientist was about as accurate in his knowledge as were the lexicographers—especially in the brick-making item; for the two elements most characteristic of clay, namely, silicon and aluminum, are wholly wanting in the human system; or, if present, they are in such small quantities as to be undiscoverable by analysis.

This example is sufficient to illustrate this particular kind of dabbling. Some thorough scientific man makes a discovery, which is briefly alluded to in some foreign journal of popular science. The periodi-

cals on this side of the ocean, catching up the allusion, dilute it still further, and presently it becomes a sort of intellectual goose-pond for these dabblers to disport themselves in. The clear fountains of knowledge from which it sprang are lost to sight, and only a mud-puddle remains in view.

Let me now sum up briefly my object in writing these pages. I have not written them to attack either clergymen or journalists, for I will not attempt to deny that much useful scientific knowledge finds its way to the popular mind through the pulpits and the newspapers. My purpose is twofold: First, to call attention to the silly character of much of what is called "popular science;" and, secondly, to urge upon true scientific men the importance of rendering real knowledge more accessible to the masses. There is a demand for science, or the trash which is written would not be read. It works into nearly all departments of common life, and is, in one way or another, of immediate interest to almost every one. Yet, as I have already said, the current popular lectures upon scientific topics are frothy and worthless: the theologian often misrepresents science for partisan purposes; and the newspapers, with all the good they may do, are too frequently conducted by those ignorant of all science. The people seek for knowledge, and unwittingly get much chaff with their wheat. In some respects the popular mind is filled with absurd superstitions. Strange psychological phenomena are attributed to "animal magnetism," and other natural wonders are apt to be fathered upon electricity. The latter innocent force is made responsible for almost every thing unusual. Therefore it seems to be time that true students of science should seek to popularize their learning. Faraday, Tyndall, Huxley, and others, have done an admirable work abroad, and their example should be more generally followed here. Our lyceums need more scientific lectures, and our best thinkers and observers should be ready to work in that direction. Men of science constantly lament that the government does not extend more aid to scientific research. The government is a popular one, and the people must be trained before its help can be expected. Therefore, it is for the interest of the teachers as well as for the good of the people, that scientific truths should be popularly put forward in simple, untechnical language, and made accessible to all.

TOWN AND COUNTRY AS PRODUCERS OF INTELLECT.

By G. M. B.

THE last number of the *Journal of the Statistical Society* had an interesting article, by Mr. Hyde Clarke, on the "Geographical Distribution of Intellectual Qualities in England."

The writer proves, by the use of a numerical test, that the towns

contribute most of the intellectual laborers of note, and that the popular notion that genius is generally of low origin or derived from obscure districts is a mistake. Some "village Hampden," it is true, may adorn the region of politics, but this is an exceptional distinction. It is needless to premise that Mr. Clarke has considered the influence of population, and has not merely enumerated the clever men from given places. He has taken 2,000 names of men of genius or high intellectual powers, and sorted them out into districts, and this forms the basis of his calculations. He says:

The more important matter is to ascertain how far the external influence of the community has affected the birth or production of men of ability, genius, or celebrity, exemplified in intellectual endowment. . . . On the whole, such men are rather born in towns than in the country, and examples to the contrary, as those of Newton, Dryden, etc., admit of explanations which neutralize their apparent antagonism.

Speaking of the preëminence of London in the production of such men, he says:

If we test this for other countries, whether in ancient or modern times, we shall find the same thing. Rome and Athens will assert a metropolitan position, and so will Paris. A map of the geographical distribution of such elements will safely mark out the most famous cities of antiquity. A map of England, of France, of Germany, or Italy, will show the like modern results. The town population being the smaller portion in each country, yet the larger number of names will belong to the town population, and not to the rural population; and, on the whole, the names which can be marked as first and second class will belong in the larger proportion to the town population.

Of the 2,000 names, three-eighths belong to the country, and five-eighths to the town districts.

The following extracts give the main points in the interesting analysis:

In regarding the distribution among the town population, again, the unequal distribution gives in most cases a larger *pro rata* proportion to the large towns over the small. The most striking case is, however, that of London (333), and, as that is supported by the example of other metropolitan cities, ancient and modern, it can be accepted as an authenticated fact that the larger the population the larger the proportion of distinguished men. Edinburgh gives 73, and Dublin 53. The proportion of those metropolitan cities to the whole number is about 22 per cent. Still, on examining the smaller towns among themselves, this by no means holds good. Many small towns furnish more names than those of larger population, and these will be found to be cathedral and university towns. What is to be marked is the low position of such great modern centres of industry and population as Manchester, Liverpool, Birmingham, Sheffield, Leeds, Hull, Bradford, etc. . . . The relation of names may, therefore, be considered to be, not to the population generally in gross, but rather to the classes engaged in the pursuit of learning, to the educated classes, and those in easy circumstances. This explains best the phenomena of London, and the preponderant towns, and likewise what may be called the intellectual

rise of the manufacturing cities in modern times. . . . It does not appear to be the case, on the whole, that men of distinction spring from the lowest classes, as some assert. It may be that such a man is the son of a poor man, or of one in an inferior trade, but the greater men are ascertained to spring from gentlemanly families or from families formerly in easy circumstances. The popular belief is the other way, because we have books giving the names of those who have risen from the lowest pursuits.

From a table given, it appears that out of the 2,000 English writers of celebrity, only 58 exercised a mechanical trade, and only 40 were sons of such, thus giving a total of only 3 per cent. connected with such occupations.

The conclusion to be drawn is, that intellectual exertion is not manifested in the lower classes, or in the children of such, to the same extent as in those where the means of instruction are more available.

This seems corroborated by a glance at the relative proportion of distinguished men in the several districts of England. The south and south midland districts contributed 60 per cent., the north and north midland 17, Wales 1, Scotland 12, and Ireland 4 per cent. The low figures for Wales and Ireland are accounted for by the Celtic language prevailing, the influence of this being further shown by the fact that Cornwall produced 21, and Devon 97 instances, though the two counties join.

London has produced, not only in number, but also in value, a larger portion of the celebrities of the country—Milton, Spenser, Pope, Byron, Chaucer, Cowley, Gray, Surrey, Herrick, Keats, Johnson, Fletcher, Gibbon, Mitford, C. Mill, Camden, Bacon, Canning, Fox, Blackstone, De Foe, Arnold, etc. . . . The facts appear to show that literary attainments are in relation to literary culture, or the culture of the educated classes, and not of the uneducated classes. . . . The development of intellectual improvement cannot be effected by sole exertion of the nervous system, but by the proper application of all the faculties dependent on the physical condition of men. It is, in fact, a creation of selection on the best principles.—*Journal of Mental Science.*

CIVILIZATION AS ACCUMULATED FORCE.

By L. DUMONT.[1]

THE word *civilization* is of somewhat indefinite meaning. It were easy to say which of the two is the more civilized, a European or a New-Caledonian savage. But, when we have to assign their respective ranks to two civilized nations, the case is more difficult. Each philosopher has his own definition of civilization. One will say that

[1] Translated from the *Revue Scientifique*, by J. Fitzgerald, A. M.

civilization is the social fact of the increase of wealth. But even though we take the word wealth in its widest sense, it will not include all the elements of civilization, and especially it will not include those which have their seat in man himself, such as moral and physical development. Then an accident, such as conquest, might enrich a nation, without advancing it in civilization.

Guizot makes civilization depend chiefly on political institutions. According to him, it is the perfectionment of civil life, the development of society, and of the relations of man with man. But he admits that we must also take into account individual life, the inner life of man and his development intellectually, socially, and morally. In his History, however, Guizot almost altogether disregards this element, so that we may consider his work as merely an excellent history of political progress under constitutional monarchy.

Buckle's History is the antithesis of Guizot's. Here the individual is every thing; institutions nothing, or even hinderances. The state, according to Buckle, is a resultant, not a principal. Buckle also denies that religion is a factor in working out the problem of civilization. These views, at first warmly opposed, are now more favorably received.

But since he deduced civilization neither from religion nor from political constitutions, how did he account for it? He defined it to consist in the supremacy of intellectual laws over physical laws. The history of Europe, as he read it, is simply a series of victories gained by man over Nature; whereas, the domination of Nature over man causes the irremedial decadence of Oriental nations.

We will not deny the justice and truth of this line of observation. The contest between man and the outer world, the conquests of science, the subjection of all the forces of Nature to man's will—these are truths as clear as day. And yet we do not believe that they constitute the sum total of civilization. Men are brought face to face, not alone with Nature, but also with one another. We have to adapt ourselves, not alone to physical forces, but we have also to adapt ourselves to one another; in a word, we find in civilization, in progress, a social as well as a physical element. Side by side with the conquests of humanity over the remainder of the universe, there is a progress in morals, and in the relations between man and man—between one society and another. Civilization is impossible without freedom and security, and these can exist only in virtue of social institutions.

All the theories we have been considering contain an admixture of truth and error; and they are all imperfect, being true in what they affirm, but erroneous in what they exclude from consideration. We have, therefore, to discover a formula which, while it applies equally to all these facts, and sums them up in a more general notion, shall show their intimate connection and their close association with one another.

I.

Civilization is *the result of previous progress.* Progress is a movement; it is, so to speak, *dynamical.* Civilization is a state, it is *static.* It is not the work of the present moment; it is rather that which the present inherits from the past, in the way of science, art, discovery, wealth, customs. In a society which is in process of civilization, each generation finds a certain store of the elements of civilization at hand. The scientific researches of the past have not to be commenced anew; its discoveries and industrial processes we have but to learn and to perpetuate. Agriculture has made progress, cities have been built, roads constructed, and society organized. Finally, we have language ready formed, and race instincts, and moral and intellectual qualities, more or less developed. So that we may regard civilization as the sum of human enjoyment at a given moment, which is at hand without the necessity of going in search of it. Or, in philosophical language, we say that civilization is an accumulation of force in the race, or for the race.

We have used the word *force*, and this calls for an explanation. Modern philosophy is inclined to see nothing but forces in the universe. Those things which we regard as *material* are but forces, or combinations of force. Light, heat, solidity, weight, and movement of every kind, are forces: life is an organization of force, and society an organization of living forces. The same is to be said of will, ideas, sensations, truth, right, science.

We may regard man as an aggregation of forces, physiological, intellectual, and moral. This aggregation is susceptible of perfectionment, its component parts becoming mutually better adjusted, or the combination becoming more complex. In either case the result will be an enlargement of the faculties and an increase of the individual's power.

But let us pursue this subject further. This system of forces which we call man is surrounded by forces which are unintelligent. He enters into competition with these, and turns them to his own advantage, appropriates them, and thus, as it were, projects his own personality outward. By the aid of science he makes Nature subject to him, and renders the most sterile soil productive. Mountains are tunnelled, and seas joined together. These and similar splendid achievements are not accomplished by the native forces of man, yet they bear the marks of man's handiwork; and the forces which did bring them about were in subjection to him. Though these forces, then, cannot be properly called *human* forces, still they are *humanized*, and it is the accumulation of both these kinds of force that makes up civilization.

It were inexact to say that this accumulation is a creation of force. Man does not *create*, he only transforms. Production implies only adapting things to our use. Therefore, when we speak of production,

we imply only a new direction given to forces already active. But man is also a consumer of the wealth he acquires and of his own powers. In order, therefore, that he may accumulate, production must be in excess of consumption. Every act we perform involves an expenditure of muscular or intellectual energy; and the same is true with regard to the implements we employ for our work. If, however, by such expenditure we render available for human uses what before was unserviceable, and if this acquisition is of greater value than the outlay, there is a clear profit for humanity. Yet this gain has no value as a civilizing element, except in so far as it puts man in the way of making new products, whether by augmenting the power of his organs or faculties, by putting in his hands a new implement, by leading to some useful discovery, or by affecting favorably political relations, which in turn react upon production and upon progress in general.

This excess of production over consumption is not the only source of power. There is another which is of equal importance, and that is the perfecting of organization, whether among the forces which make up the individual, the society, or the race. Here, again, there is no creation, but only utilization of force. This organic adaptation diminishes friction, and permits the utilization of forces which else would be wasted. Organization, furthermore, brings together like capacities, and enables them to combine their strength, and thus forces which separately would be weak, being united, produce great results. In thus grouping together like forces, the first step is to detach them from those which are dissimilar, and consequently a perfect organization leads to the separation of faculties, the localization of functions, and the division of labor. We now proceed to confirm our inductions by particular applications of them to actual facts. And, first, we will consider those elements of civilization which are extrinsic to man. We can more easily understand the world around us than the interior phenomena of the mind, and the study of these external phenomena will furnish us with many analogies to guide us in the study of the more recondite internal phenomena.

II.

The word *capital* is employed to denote the sum of external forces accumulated by man, and which he can use for new productions. We do not, however, agree with certain contemporaneous economists who say that capital is only labor accumulated. This definition, though plausible, is inexact, and besides it involves a dangerous confusion of ideas, and has supplied the socialists with a portion of their arguments against capital, civilization, and political economy itself.

No doubt capital is an accumulation, but not an accumulation of labor; it is not even the product of labor. Though Proudhon ("Manuel du Spéculateur") defines capital to be "labor accumulated," he contradicts himself a few lines farther on, when he says, "The first

capital is given gratis to man by Nature." Most of the precious metals possess a value in excess of the cost of production; the difference represents a portion of capital which does not come from labor, and the value of which is regulated simply by the law of demand and supply. Capital, then, is not always the product of labor, nor does labor, even when accumulated, always produce capital. There is such a thing as destructive labor, as, for instance, under the rule of the Commune in Paris. There is also such a thing as unproductive labor, as when thousands of working-men are employed for weeks together in preparations for *fêtes*, illuminations, and the like. An author may spend years in writing a work which no man will read or buy. He surely does not produce capital. Finally, if capital were in reality only labor accumulated, would not the complaint of the socialists be justified when they clamor against society for its iniquity in making the workers non-capitalists, while the capitalists are not workers?

It is better to regard capital as the *condition* of labor, and not its product. As for the origin of capital, to fix it precisely, we need only apply the general formula already given, according to which capital represents the excess of production over consumption. It means savings, therefore, or, if you wish, accumulated savings. One begins to acquire capital, not by labor, but rather by saving the products, whether of labor or of Nature. Hence it follows that a just distribution of capital must be based, not on the amount of labor, but on the amount of saving; and this is about the state of things existing in the present social order, allowance being made for some imperfections. The spendthrift wastes his capital; and he alone produces it, or increases it, who can save. Many persons, who are not at all socialists, discourage saving, and judge it better to expend capital than to consume it. It is true that expenditure in some measure benefits our contemporaries; yet only at the expense of society in the future; whereas, saving contributes to the future growth of civilization, though doing some little injury to the present generation. Now, shall we sacrifice the present for the future, or shall we compromise the future in order to alleviate the misery and suffering of the present? Let us put an hypothesis which, though impracticable, still may be supposed. Suppose France were to resolve to use up all her wealth in one day. During that one day all Frenchmen might have all sorts of enjoyment. But the morrow!

We must remember that the race is in process of development, and is never at any moment what it will be. The present is nothing. To insure progress, the first requisite is that capital should increase. Here is a quantity of grain which might subsist a family for one day: save it, turn it to account, and it will produce food for millions. Such is the benefit of saving, and this is the secret of material civilization, which is itself the result of foresight and of past privations. The nations which are at the head of material civilization are those whose institutions have most favored saving, by their respect for private

property, and the safeguards they threw around capital. Unhappily, in modern European legislation, there are still to be found enactments which are nothing better than attacks upon the rights and liberties of capital. If a man has to save not alone for himself, but also for others, his economy will be more strict than if he had to save for himself alone. If you do away with the right of freely disposing of property, a man will take care to consume all his capital, rather than let it fall into the hands of those for whose benefit he has no mind to accumulate.

The accumulation of capital is often regarded with alarm, which, however, is baseless. We must not forget that capital is only the means of production, and that consequently it must always be profitably employed, else all its value is gone. Where capital is abundant, the capitalist is constrained to lend it at reasonable rates, and to go in search of labor, in order to find an advantageous investment. On the other hand, when there is but little capital, then labor must go in search of the capitalist, and pay him whatever interest he requires. Thus, individual property and the liberty of disposal are upheld by the very arguments that socialists bring to overturn them. The chief benefit of these institutions is to make accumulation of capital possible: this the socialists regard as an injury, for their aim is absolute equality, and they make small account of the interests of civilization. But we who regard civilization as the great aim of humanity find no more difficulty with inequality of capital than with inequality of wages. Some workmen get ten or twenty times as much pay as others, and some save ten or twenty times as much as others. If the capitalist has only to preserve what others have accumulated, or what has come to him by gift or inheritance, does not the workman in like manner profit by his capital of health and intellectual faculties, which he owes partly to inheritance and partly to his education, in order to demand higher pay?

In no country is the habit of saving so general as in France, and this is the securest basis of our prosperity and civilization. The French have been unjustly charged with prodigality; but the reproach should be confined to that *quartier* of Paris which lies between the Champs Elysées and the Faubourg Montmartre. Without these bounds, all France is steady and industrious. A very moderate estimate puts the annual increase of wealth in France at three milliards of francs. Unfortunately, however, we lose much of the benefit of this saving as a nation by embarking in ruinous adventures. The national debt, which will soon be twenty milliards, has doubled within twenty years. Though we make an annual increase of capital to the amount of three milliards, we annually burden posterity with a debt of a half milliard. Another and more serious defect of the French nation is, that this saving tends to check population; and this fact leads us to consider another element of civilization, viz., the value of the individual.

III.

As regards civilization, we may consider man from a threefold point of view: the numerical quantity of the population; the duration of human force, that is, longevity; and the intensity of this force, that is, the development of the organs and faculties.

Man being a combination of forces, does it follow that an increase of population is an accumulation of human forces, and so an element of civilization? As the increase of wealth favors the increase of population, so the latter reacts on the former by increasing the number of producers, and especially by favoring the division of labor. Consequently, a country's well-being requires a just equilibrium between the sum of the capital and the number of inhabitants. An increase of population ought not to lead to a loss in capital, nor ought the increase of capital, by saving, lead to diminished population. In the former case, the country would become impoverished; in the latter it would decay. The latter is the case with France, where the population is far less than the immense resources of the country would justify. While Saxony doubles its population in 45 years, England in 49, Prussia in 54, Russia in 56, Würtemberg and Switzerland in 114, France requires more than 198. There is reason to suppose that Great Britain, which now has 26,000,000, will, in 50 years, have 52,000,000; Germany, 60,000,000; and Russia, over 100,000,000; but France, unless there occur a change, will have no more than 45,000,000. At the beginning of this century, the annual increase of population in France was 175,000, now it is only 132,000 souls. Far from peopling our colonies, we find the very soil of France gradually encroached on by an immigration of the neighboring nations.

The reasons for this are numerous. The restrictions laid on the father of a family in France are greater than in most countries. Then the education Frenchwomen get has an influence. Marriages are not fewer than hitherto, but are contracted at a later period of life. In Catholic countries there is less moral freedom but more licentiousness than in Protestant countries. In the latter, marriage is rendered easy and spontaneous by the greater freedom of social relations between the sexes; but in France marriage is a matter of calculation, and marriages are generally contracted with the aid of go-betweens. Another cause is that habits of industry and especially individual enterprise are not at all in France in proportion with the national wealth. While in England a man generally acquires capital with a view to better his condition as a producer, a Frenchman's study is to retire from business, and leave to a very small family the means of living without work. We have also in France a large proportion of the poorer classes who flock into the great cities to live by public assistance. We have by no means exhausted all the resources of our soil, and there are 20,000,000 acres of waste land. Though in

France the population increases more slowly than in other European nations, the average duration of life is greater. The higher the average duration of life, the greater the accumulation of productive forces. The reason why war is so fatal to civilization, even among the conquerors, is that it destroys those who are at the age most favorable for production.

We have now to consider the third element of civilization, as found in man himself, and this is the most important of all, namely, the intensity of force. Two equal quantities of individuals will not in the same space of time produce equally, for each may not possess the same energy, the same intensity of life or force. Individual values are determined by the development of organs, functions, and faculties, which come in part from exercise and culture, and in part from inheritance. On the one hand, we have the habits acquired by the individual, which are modified by his surroundings; and, on the other hand, we have habits rooted in the family, nation, or race, and which become hereditary. The latter is called an instinct, and embraces all those sentiments which men have in common, their intensity being in proportion with the social progress which produced them. The influence of these inherited sentiments is very great, though it is frequently overlooked. If a man is what he is as distinct from all others in virtue of individual development and personal character, we are men having our specific and race character from inheritance. We are possessed of the apparatus of vision, hearing, language, circulation, digestion, because these functions are so many habits that have become essential to the human race.

These habits and instincts are not all good, for vices too are habits. This means only that the action of our organs and faculties sometimes takes a direction unfavorable to society or humanity. The body has its diseases, the understanding its errors, and the will its vices. Entire races have sometimes depraved instincts, which forbid their advancing beyond a certain degree of civilization, while others fail to attain that intellectual development which is the condition of all ulterior progress. Now, what is the criterion for determining what habits are good and favorable for civilization? We need only apply our general formula, and then we shall see that those habits have a civilizing influence which tends to increase man's forces, the power of his faculties, his value as an intellectual or material producer. On the contrary, those habits which have a tendency to deprave the individual, weaken his faculties, or efface his moral instincts, are vices which, when generalized and transmitted, whether by education or by inheritance, lead a people toward decay, decrepitude, and extinction. The ideas, instincts, and moral habits of the individual, are ever in competition, and, when this competition tends toward perfection, the element which wins in the struggle always gains power by selection.

It was the fashion during the eighteenth century to regard the

faculties of the civilized man as inferior to those of the savage. Experience has not confirmed this. What certain organs have lost in one direction, they have got back in another. If our senses have a narrow range, they have gained in firmness of perception. The senses of touch and of taste are in the civilized man extremely subtile. Our power of vision has not a very great range, but we can peruse for many hours together the printed page, a thing which the eye of the savage could never do. If our ear cannot detect the stealthy approach of a wild beast, it can appreciate the nicest shades of difference in musical notes. We cannot climb trees, but a clerk seated at his desk does more work with his hand in one day than a savage in a twelvemonth. Finally, the muscular force of certain Indian tribes has been proved by the dynamometer to be very considerably less than that of English and French sailors.

There are faculties which appear to arise full grown, so to speak, when civilization has reached a certain stage, and which do not exist, even in germ, among savages. Such are the faculties of literary and artistic taste. The savage has no leisure for the pleasures of the imagination. A Molière, a Rembrandt, or a Mozart, would have to expend all his energy under such circumstances in procuring the bare necessaries of life. The fine arts are subordinated to the development of the other elements of civilization, but they may also be regarded as the best expression and the most exact measure of the state of a society. A few examples will explain our meaning:

How has architecture advanced? Men at first dwelt in hollow trees, in caves, or beneath any chance shelter. Next, they constructed rude houses of stones, branches, or sods. It was only at a later period that they could think of symmetry or regularity. Then came all kinds of ornamentation. At last they came to erect structures without direct utility, for æsthetic purposes merely, such as columns, porticoes, and the like. And so each increase of wealth in a society is followed by a corresponding progress in arts which are rather pleasing than useful. The same holds with respect to literature. At first, men would interchange only thoughts of immediate utility. Next they came imperceptibly to adorn their speech, and then arose history, religion, morality, philosophy, adorned with all the charms of versification, music, and poesy. It was only at a later period that poetry appeared in its own individual character, on the stage, or in the story, as the form in which pure fiction was to be cast, having as its aim to please the imagination, without reference to history, religion, or utility. In a word, art and poetry spring from a superabundance of intellectual energy, and from an exuberance of ideal force.

The culture of science, as viewed with reference to civilization, is the same thing as the development of the understanding. At first view, we might suppose that scientific truths, when once discovered, constitute a sort of capital, which may be stored up. But this is not

the case, for science has no real value, except as it is present in the consciousness of the thinker, and it is inseparable from the exercise of the faculties. Science in books is of no importance for civilization. We will not speak of the immense importance of intellectual development, which Buckle regarded as the very essence of civilization. The mode of this development is a question for a theory of progress. It consists principally of an enlarging adaptation of ideas to external facts, and to one another; and the most natural explanation will be given when we apply Darwin's admirable inductions to the formation of ideas.

The French have boasted that they were the leaders of civilization in virtue of their intellectual superiority. But the Germans and English make the same pretensions. Yet the French mind appears to hold preëminent rank in certain respects, as for instance in taste for the beautiful, for grace, and for elegance. The country which produced Molière is now the only one that has a theatre worthy of the name; our painters are the first in the world; and in France alone are the refinements of an exquisite taste exhibited in the minor details of every-day life. We owe all this to the æsthetic influence of the capital.

The French mind also excels in all the lively and brilliant qualities of imagination. Still, it must be admitted that these qualities are blended with very grave defects. The philosophical faculties are in some degree weakened by the development of taste, and the refinement of the imagination often hinders the cultivation of the reason. We have, to be sure, some men of great distinction in all the sciences, but it cannot be gainsaid that instruction is not as wide-spread in France as in Germany; and moral science is far more backward here than in England. We have no taste for consecutiveness, method, long deduction, or patient analyses.

These defects expose us to grave dangers in political life especially, and this brings us to the consideration of social relations and institutions as they have a bearing upon civilization.

IV.

There are two things to be considered in the social order, viz., the rights of individuals, and the system of institutions guaranteeing them. As the definition of these rights depends on the development of the race in their ideas, morals, instincts, etc., we need but refer to what we have already said on the development of organs and faculties, to show how far these rights extend. But the case is different with governmental institutions which derive force not from the progress of individuals, but from the evolution of society, and the historic development of the nation. In times of order and tranquillity we are disposed to reduce governmental functions to the minimum. For this reason, prosperity sometimes leads to decadence. When the government is weakened, the

nation compromises its civilization, and lies open either to anarchy or conquest, or both. Governmental progress is never made by radical destruction or suppression of established order, with a view to evolve a new organization, giving up historic advantages. Gradual modification is the condition of true progress, for no constitution or organization is of any value, unless it is the work of ages.

In order to guarantee security and respect for individual rights, the government derives a certain amount of force from the nation, and this force makes up the power of the state. The value of a government is to be estimated by the difference between what it costs and the benefits it secures. If we would know what is the value of French political institutions, for instance, we have only to estimate the value of our present capital, and compare it with what we should have were our institutions at an end. Hence, we see that political institutions are a true civilizing force, as yielding an excess of utility over expenditure.

A political society is an organism, and the individuals may be regarded as elementary cellules. Social progress consists in the increasing adaptation of individuals, which results from the separation of functions and the division of labor. Just as, in the lower grades of the physiological scale, one organ will discharge many very diverse functions, so, in the more imperfect forms of society, the government discharges every kind of office, as that of the soldier, priest, school-master, tutor, manufacturer, agriculturist, merchant, banker. The great problem is, to determine what is to be done by the state, what by other forces. The government will be more effective in proportion as it is freed from the embarrassment of diverse functions.

From this point of view we should say that France has departed from the path of progress in two directions: First, her revolutions have unduly weakened the government; second, public opinion has unduly favored the extension of governmental interference. The result of the first is, that no government in France is sufficiently strong; the result of the second, that government is entangled in affairs from which it were better freed, and every schemer and visionary is clamoring for government assistance to work out his plans.

Every ephemeral constitution we have had, has to-day a factious party ready to do battle for it. Thus, every administration finds itself surrounded with a coalition of minorities. Time alone can give authority to any constitution.

Not less serious are the consequences of Utopianism which would shape the state according to every fantastic notion. All forms of socialism strive to enlarge the action of society; and communism, its latest development, seeks to absorb the individual in the state. Governments have often unconsciously yielded to the influence of these dreams, as we see where they favor protection, state interference in religious matters, and in the direction of art and science, etc.

The university, too, is to blame for our disasters. Its metaphysics

and worship of forms give rise to dreams of Utopia and all manner of illusions. We had little better than illusions to oppose to the sternly practical science of Germany. It is Utopian ideas that have produced, after a disastrous war, another crisis more serious still. Only solid, positive education can avert such disasters. England has opposed to fanciful dreams the serious study of political economy. Germany has profoundly studied the historical sciences, and has cultivated a searching criticism as well as the natural sciences. But France has followed an ideal, without regard to facts, and the result is, that every thing is in a state of disorder.

Present disaster may bring France to her senses, and induce her to start from different principles.

POPULAR GEOLOGY.[1]

By Rev. CHARLES KINGSLEY.

GEOLOGY is the science which explains to us the *rind* of the earth; of what it is made; how it has been made. It tells us nothing of the mass of the earth. That is, properly speaking, an astronomical question. If I may be allowed to liken this earth to a fruit, then astronomy will tell us—when it knows—how the fruit grew, and what is inside the fruit. Geology can only tell us at most how its rind, its outer covering, grew, and of what it is composed; a very small part, doubtless, of all that is to be known about this planet.

But, as it happens, the mere rind of this earth-fruit, which has, countless ages since, dropped, as it were, from the Bosom of God, the Eternal Fount of Life—the mere rind of this earth-fruit, I say, is so beautiful and so complex, that it is well worth our awful and reverent study. It has been well said, indeed, that the history of it, which we call geology, would be a magnificent epic poem, were there only any human interest in it; did it deal with creatures more like ourselves than stones, and bones, and the dead relics of plants and beasts. Whether there be no human interest in geology; whether man did not exist on the earth during ages which have seen enormous geological changes, is becoming more and more an open question.

But meanwhile all must agree that there is matter enough for interest—nay, room enough for the free use of the imagination, in a science which tells of the growth and decay of whole mountain-ranges, continents, oceans, whole tribes and worlds of plants and animals.

And yet it is not so much for the vastness and grandeur of those

[1] From advance sheets of Prof. Kingsley's excellent little book entitled "Town Geology."

scenes of the distant past, to which the science of geology introduces us, that I value it as a study, and wish earnestly to awaken you to its beauty and importance. It is because it is the science from which you will learn most easily a sound scientific habit of thought. I say most easily; and for these reasons. The most important facts of geology do not require, to discover them, any knowledge of mathematics or of chemical analysis; they may be studied in every bank, every grot, every quarry, every railway-cutting, by any one who has eyes and common-sense, and who chooses to copy the late illustrious Hugh Miller, who made himself a great geologist out of a poor stone-mason. Next, its most important theories are not, or need not be, wrapped up in obscure Latin and Greek terms. They may be expressed in the simplest English, because they are discovered by simple common-sense. And thus geology is (or ought to be), in popular parlance, the people's science—the science by studying which, the man ignorant of Latin, Greek, mathematics, scientific chemistry, can yet become—as far as his brain enables him—a truly scientific man.

But how shall we learn science by mere common-sense?

First, always try to explain the unknown by the known. If you meet something which you have not seen before, then think of the thing most like it which you have seen before; and try if that which you know explains the one will not explain the other also. Sometimes it will; sometimes it will not. But, if it will, no one has a right to ask you to try any other explanation.

Suppose, for instance, that you found a dead bird on the top of a cathedral-tower, and were asked how you thought it had got there. You would say, "Of course, it died up here." But if a friend said: "Not so; it dropped from a balloon, or from the clouds;" and told you the prettiest tale of how the bird came to so strange an end, you would answer: "No, no; I must reason from what I know. I know that birds haunt the cathedral-tower; I know that birds die; and therefore, let your story be as pretty as it may, my common-sense bids me take the simplest explanation, and say—it died here." In saying that, you would be talking scientifically. You would have made a fair and sufficient induction (as it is called) from the facts about birds' habits and birds' deaths which you knew.

But suppose that when you took the bird up you found that it was neither a jackdaw, nor a sparrow, nor a swallow, as you expected, but a humming-bird. Then you would be adrift again. The fact of it being a humming bird would be a new fact which you had not taken into account, and for which your old explanation was not sufficient: and you would have to try a new induction—to use your common-sense afresh—saying, "I have not to explain merely how a dead bird got here, but how a dead humming-bird."

And now, if your imaginative friend chimed in triumphantly with, "Do you not see that I was right after all? Do you not see that it

fell from the clouds? That it was swept away hither, all the way from South America, by some southwesterly storm, and, wearied out at last, dropped here to find rest, as in a sacred place?" what would you answer? "My friend, that is a beautiful imagination: but I must treat it only as such, as long as I can explain the mystery more simply by facts which I do know. I do not know that humming-birds can be blown across the Atlantic alive. I do know that they are actually brought across the Atlantic dead; are stuck in ladies' hats. I know that ladies visit the cathedral: and, odd as the accident is, I prefer to believe, till I get a better explanation, that the humming-bird has simply dropped out of a lady's hat." There, again, you would be speaking common-sense; and using, too, sound inductive method; trying to explain what you do not know from what you do know already.

Now, I ask of you to employ the same common-sense when you read and think of geology.

It is very necessary to do so. For in past times men have tried to explain the making of the world around them, its oceans, rivers, mountains, and continents, by I know not what of fancied cataclysms and convulsions of Nature; explaining the unknown by the still more unknown, till some of their geological theories were no more rational, because no more founded on known facts, than that of the New Zealand Maories, who hold that some god, when fishing, fished up their islands out of the bottom of the ocean. But a sounder and wiser school of geologists now reigns; the father of whom, in England at least, is the venerable Sir Charles Lyell. He was almost the first of Englishmen who taught us to see—what common-sense tells us—that the laws which we see at work around us now have been most probably at work since the creation of the world; and that whatever changes may seem to have taken place in past ages, and in ancient rocks, should be explained, if possible, by the changes which are taking place now in the most recent deposits—in the soil of the field.

And in the last 40 years—since that great and sound idea has become rooted in the minds of students, and specially of English students—geology has thriven and developed, perhaps more than any other science; and has led men on to discoveries far more really astonishing and awful than all fancied convulsions and cataclysms.

I have planned this series of papers, therefore, on Sir Charles Lyell's method. I have begun by trying to teach a little about the part of the earth's crust which lies nearest us, which we see most often—namely, the soil; intending, if my readers do me the honor to read the papers which follow, to lead them downward, as it were, into the earth; deeper and deeper in each paper, to rocks and minerals which are probably less known to them than the soil in the fields. Thus you will find I shall lead you, or try to lead you on, throughout the series, from the known to the unknown, and show you how to explain the latter by the former. Sir Charles Lyell has, I see, in the new edition of

his "Student's Elements of Geology," begun his book with the uppermost, that is, newest strata, or layers; and has gone regularly downward in the course of the book to the lowest or earliest strata; and I shall follow his plan.

I must ask you meanwhile to remember one law or rule, which seems to me founded on common-sense, namely, that the uppermost strata are really almost always the newest; that when two or more layers, whether of rock or earth—or indeed two stones in the street, or two sheets on a bed, or two books on a table—any two or more lifeless things, in fact, lie one on the other, then the lower one was most probably put there first, and the upper one laid down on the lower. Does that seem to you a truism? Do I seem almost impertinent in asking you to remember it? So much the better. I shall be saved unnecessary trouble hereafter.

But some one may say, and will have a right to say, "Stop—the lower thing may have been thrust under the upper one." Quite true: and therefore I said only that the lower one was most probably put there first. And I said "most probably," because it is most probable that in Nature we should find things done by the method which costs least force, just as you do them. I will warrant that, when you want to hide a thing, you lay something down on it ten times for once that you thrust it under something else. You may say: "What? When I want to hide a paper, say, under the sofa-cover, do I not thrust it under?" No, you lift up the cover, and slip the paper in, and let the cover fall on it again. And so, even in that case, the paper has got into its first place.

Now, why is this? Simply because in laying one thing on another you only move weight. In thrusting one thing under another, you have not only to move weight, but to overcome friction. That is why you do it, though you are hardly aware of it: simply because so you employ less force, and take less trouble.

And so do clays and sands and stones. They are laid down on each other, and not thrust under each other, because thus less force is expended in getting them into place.

There are exceptions. There are cases in which Nature does try to thrust one rock under another. But to do that she requires a force so enormous, compared with what is employed in laying one rock on another, that (so to speak) she continually fails; and, instead of producing a volcanic eruption, produces only an earthquake. Of that I may speak hereafter, and may tell you, in good time, how to distinguish rocks which have been thrust in from beneath, from rocks which have been laid down from above, as every rock between London and Birmingham or Exeter has been laid down. That I only assert now. But I do not wish you to take it on trust from me. I wish to prove it to you as I go on, or, to do what is far better for you, to put you in the way of proving it for yourselves, by using your common-sense.

At the risk of seeming prolix, I must say a few more words on this matter. I have special reasons for it. Until I can get you to "let your thoughts play freely" round this question of the superposition of soils and rocks, there will be no use in my going on with these papers.

Suppose, then (to argue from the known to the unknown), that you were watching men cleaning out a pond. Atop, perhaps, they would come to a layer of soft mud, and under that to a layer of sand. Would not common-sense tell you that the sand was there first, and that the water had laid down the mud on the top of it? Then, perhaps, they might come to a layer of dead leaves. Would not common-sense tell you that the leaves were there before the sand above them? Then, perhaps, to a layer of mud again. Would not common-sense tell you that the mud was there before the leaves? And so on down to the bottom of the pond, where, lastly, I think common-sense would tell you that the bottom of the pond was there already, before all the layers which were laid down on it. Is not that simple common-sense?

Then apply that reasoning to the soils and rocks in any spot on earth. If you made a deep boring, and found, as you would in many parts of this kingdom, that the boring, after passing through the soil of the field, entered clays or loose sands, you would say the clays were there before the soil. If it then went down into sandstone, you would say—would you not?—that sandstone must have been here before the clay; and however thick—even thousands of feet—it might be, that would make no difference to your judgment. If next the boring came into quite different rocks, into a different sort of sandstone and shales, and among them beds of coal, would you not say, "These coal-beds must have been here before the sandstones?" And, if you found in those coal-beds dead leaves and stems of plants, would you not say: "Those plants must have been laid down here before the layers above them, just as the dead leaves in the pond were?"

If you then came to a layer of limestone, would you not say the same? And if you found that limestone full of shells and corals, dead, but many of them quite perfect, some of the corals plainly in the very place in which they grew, would you not say, "These creatures must have lived down here before the coal was laid on top of them?" And if, lastly, below the limestone, you came to a bottom-rock quite different again, would you not say, "The bottom-rock must have been here before the rocks on the top of it?"

And if that bottom-rock rose up a few miles off, 2,000 feet, or any other height, into hills, what would you say then? Would you say: "Oh, but the rock is not bottom-rock; is not under the limestone here, but higher than it. So perhaps in this part it has made a shift, and the highlands are younger than the lowlands; for see, they rise so much higher?" Would not that be about as wise as to say that the bottom of the pond was not there before the pond-mud, because the banks round the pond rose higher than the mud?

ON MORAL CONTAGION.

By Dr. DESPINE.

IN his short pamphlet of twenty-four pages, the writer treats of a matter observed by all who read the newspapers—we mean the fact that crimes, particularly those of a graver description, generally occur in epidemics. To prove this point, Dr. Despine, in the first division of his paper, records a large number of murders, suicides, robberies, etc.; on these it is not necessary to dwell, but we shall pass on to his second division—the law which regulates Moral Contagion. The following is what is said on this matter:

Moral contagion, being a natural phenomenon, is consequently one of the laws to which God has subjected all created things. We succeed in the discovery of this law by analyzing moral facts and by studying the circumstances in which they occur, in the same manner as we succeed in discovering the laws which preside over the phenomena of the physical and organic worlds, by studying perseveringly the facts appertaining thereto as well as the conditions in which they are produced. Now, the conclusion to be drawn from the facts which we have related is forcibly this, which will represent the law that has directed the commission of these acts: *Every manifestation of the instincts of the mind, of the sentiments and passions of every kind, excites similar sentiments and passions in individuals who are capable of feeling them in a certain intensity.* This law explains how a certain act infects some and not others. One could not better compare man's moral nature than to a sounding-board (*table d'harmonie*). The sounding of one note causes vibrations in the same note in all the boards which, being susceptible of emitting it, are influenced by the sound emitted. In the same way, the manifestation of a sentiment, of a passion, excites the same instinctive element in every individual susceptible, by his moral constitution, of feeling more or less acutely this same instinctive element.

If this law acts beneficially in affording us the means of putting into activity, of exciting and strengthening by good example, the higher sentiments of man, it also becomes a source of evil in causing moral perversion by the influence of bad example, by the recounting of criminally immoral acts, which vivify, incite, strengthen the evil instincts, sentiments, passions, of the man whose natural *morale* is already below par. It is necessary, therefore, to take this law into serious consideration in order that it may operate as much as possible for good, and remove as far as possible those circumstances which tend to make it the source of evil. And these latter circumstances occur too frequently in our day, by the relation of hideous crimes with which

all the newspapers are filled, and particularly those which, by their low price, are intended to be read by the lower classes. If the recital of immoral, criminal acts is not dangerous for individuals of good parts, who from their mental constitution reprobate these acts with horror, who have only an aversion to what is bad, it is incontestable that, for those morally deformed, in whom the tendencies to evil are very powerful, easily excited, or already developed, either by their inherent activity, or by the corrupting influence of immoral surroundings, and in whom the moral sentiments which are antagonistic to the depraved tendencies are feeble or absent—it is incontestable, I say, and I have brought forward numerous facts in evidence thereof, that the publication of criminal acts is very dangerous to public morality and security, because it stimulates in these individuals the same depraved tendencies which had occasioned these crimes, and awakens those sentiments, those *penchants*, those passions; and the desire to commit similar acts then appears. Now, in such morally-deformed individuals, who form the unfortunate dregs of society, a class which is constantly renewed, and of which the source is never exhausted, the recital of such acts becomes to them a cause of crime, and consequently a cause of danger to society. These individuals, abnormally constructed in the moral part of their nature, real moral idiots, though perhaps very intelligent, physically well developed, and in good bodily condition; these individuals whom the public describe as heartless, whom magistrates, before whom they appear on various charges, accuse of being destitute of human feelings; these individuals in whom criminal tendencies are not commanded by the sentiment of moral duty, by moral perception, by religious feelings, and by other noble instincts of humanity; these individuals who consider their immoral and hideous desires without abhorrence, and whom crime leaves unmoved and without remorse, who, in way of regret, feel only what injures the success of their undertakings at being captured and punished—these individuals, I say, will be tempted to commit crime if an evil desire excited by example becomes more powerful than their other better feelings which, while they predominated, restrained any criminal tendencies which these persons might have experienced. This miserable scum of humanity so dangerous to society, which produces exclusively all the greatest criminals, and to which we have directed too little attention up to the present time, ought to be explored to the bottom.—*Journal of Mental Science.*

THE ENEMIES WE IMPORT.

By Prof. SAMUEL LOCKWOOD, Ph. D.

IT would seem as if every grain brought its bane. The Agricultural Department at Washington has done a good deal for agriculture in the importation and distribution of foreign seeds, slips, and plants. In this way have been secured to the country many of the choicest improved plants from abroad, and many entirely new to our gardens. But it is to be feared that, in some instances unavoidably, and in others from want of care or skill, or both, the eggs and larvæ of foreign insect-pests have been introduced, and are to-day troublesome to the husbandman, and a source of mischief and loss to the interests of the nation at large. If that man, or that art, is a public blessing that makes a spear of wheat grow where the land was sterile before, or makes that bear twofold that before did little more than barely reproduce its kind, surely, then, that is a pest and misfortune that appears as a new destroyer of the anticipated harvest. So far as size is considered, the little fly introduced in the provender of the Hessian soldier, in 1776, is contemptible; yet it was destined to become an enemy more formidable than the troops that brought it. So diminutive, indeed, is this pest, that many a husbandman has never seen it to know it, and, in fact, only knows it from its sad depredations on his honest labor; which are such that all the combined whirlwinds and destructive storms that have ever swept over portions of our land have not robbed the national wealth so much as this almost invisible, tiny creature, that dances in the sunbeam; which science well names *Cecidomyia destructor*, and which tradition calls the *Hessian fly*.

In Freehold, N. J., in the autumn of 1870, I detected a new-comer making terrible havoc with the cabbage. This esculent was entered from without, and almost honey-combed by a small green caterpillar, that I had never seen before. It was soon determined to be the *Pieris rapae*, or cabbage-caterpillar of Europe. The parent was a pretty butterfly, mainly white, with black spots on the wings. It first appeared on this continent at Quebec, and made its noxious power felt in the destruction of the cabbages to the amount of many thousands of dollars in that neighborhood. It soon came into Northern New England, and in 1869 was found in the gardens within a few miles of New York. At Freehold, of course, it was stretching south. It soon reached Philadelphia. Last summer it was at home at Baltimore, and this June it has appeared at Washington. The terrible little beauty is thus belting the land with a scourge.

Among the insect pests that have become celebrated because of its fearful capacity of increase, the grasshopper deserves mention. It is

well known that in Russia this insect appears in such prodigious numbers that the wheels of the vehicles roll crushingly through the masses. Mr. Glover, the entomologist of the Department of Agriculture, states that a new grasshopper has appeared. Besides several larvæ and part of an entire insect found when cleansing the pots in the greenhouse of the department, a pair of these strange creatures, a male and a female, has been obtained. They went lustily to work on the leaves of the coffee-plant, bananas, etc., in the greenhouse, "much in the same manner as is done by our native katydids, by eating holes in the leaves and gnawing away the edges. Their jaws were remarkably strong and sharp, and when the insects were incautiously handled they bit so severely as to draw blood. The male was about 1.75 inch in length from the tip of the cone, or horn on its forehead, to the end of its wing-covers when closed. The female measured 3.05 inches to the end of the ovipositor, which itself was at least 1.25 inch in length. The general color of both male and female was a light pea-green, and the wings were delicately veined with distinct nerves, resembling the venation of leaves. A very marked feature in this insect, when alive, is that the labrum and clypeus are bright yellow, contrasting strongly with the jet-black of the mandibles, which, together with the cone or horn on the top of its head, gives it a remarkable appearance. This cone or horn, which is placed obliquely upward on the top of the forehead, forming a line with the face, is yellow beneath, black at the tip, and ends in an acute point, which is somewhat bent downward at its summit. No insect resembling it having hitherto been found in this neighborhood, there is but little doubt that it has lately been imported with or on some foreign plants sent from South America or the West Indies; and, as many exotic plants have been received from Balize, British Honduras, it is probable that this grasshopper came in the egg-state, on some of the plants from that locality, and was hatched out last summer in the greenhouse. This fact alone admonishes us how careful we should be when importing new and valuable plants from abroad, for, if a large insect, nearly two inches in length, and fully the size of a katydid, can be so easily introduced, how much more readily the small and inconspicuous noxious insects hidden under the bark would be likely to escape notice, until they had perpetuated their species, so as to become partially naturalized and injurious to our plants! There is no danger, however, that this grasshopper will spread, and, as it is apparently very tender and accustomed to a tropical climate, most probably it would not be able to withstand the rigors of our winters in the open air, and as all were killed or caught as soon as seen in the greenhouse, there is very little probability of any being left to perpetuate their race." Mr. Thomas has described this insect under the name of *Copiophora mucronata*, in the "Canadian Entomologist."

More curious and perhaps more interesting to scientific consideration is the appearance, in the hot-houses of the Agricultural Department,

of a *new earth-worm.* The species is very large, and, compared with our common angle-worm, it is very curious. It has multiplied in the hot-houses of the department so as to have become a real pest. It is believed to have been introduced from Japan in the earth with the plants imported in the expedition under Commodore Perry. Mr. Glover seems to think it is the same as the worm now doing much damage to pot-plants in the hot-house conservatories of England, and quotes Mr. Fish in the *English Gardener's Chronicle*, who speaks of "the eel-worm" as "probably a tropical relation of the common earth-worm, as it cannot live out-of-doors in the climate of England, and scarcely subsists in a greenhouse, but revels in the temperature of a plant-store or orchideous house. It differs from the common worm in its mode of locomotion, and in several of its habits. It comes out at night on walls, stone floors, etc., and is as quick as an adder in its movements when disturbed. It seems impossible to eradicate it; it appears to breed with extraordinary rapidity, and is endowed with great muscular power, so much so that it is somewhat difficult to hold a large specimen between the thumb and finger. Lime-water, which is a sovereign remedy against the common earth-worm, appears to have little influence on it, and the only effective mode of destruction is to turn out the soil from the pot and catch and kill the intruder, taking care, however, not to knock or jar the plant, as this worm, instead of coming to the surface on being disturbed, like the common worm, will instantly recede to the centre of the ball of earth and remain there undisturbed. Mr. W. Baird speaks of a worm under the name of *Megascolex* (*Perichæta*) *diffringens*, found in three different gardens in England, in hot-stove houses, which is probably the same as the eel-worm referred to by Mr. Fish."

If, in the blatant ethics of the pot-house politician, "eternal vigilance is the price of liberty," in a sense certainly of equal importance it behooves that, even in disseminating these matters for the common good, science should dictate the method, and the economist practise the care that shall conserve the good while it separates the bad. But only of its best and noblest minds can the age exact the task of separating wisely and well its blessings and its bane.

EDITOR'S TABLE.

THE RECENT STRIKES.

THE eight-hour epidemic has at length subsided, and the working-men, having failed to accomplish their object, have generally returned to their labors under the old arrangements. The infection spread through all the leading industrial crafts: carpenters, bricklayers, cabinet-makers, upholsterers, carriage-makers, iron and metal workers, piano-makers, plumbers, sugar-refiners, gas-makers, car-drivers—one after another—were drawn into the movement. Laborers have had a trial of strength with capitalists, turning out some 80,000 strong, with much agitation and the best organization that could be rallied; yet the movement collapsed in less than three months from its outbreak. The details of the struggle it is unnecessary here to specify, as they have been extensively published by the newspaper press, but its leading results may be summed up as follows: 1. The loss of a couple of million of dollars to the mechanics concerned; 2. The consequent privation and suffering of many families; 3. The demoralization of the unemployed through idleness and exposure to vicious influences; 4. Extensive loss to capitalists and the public through the closure of manufactories, non-production, and business derangement; 5. An aggravation of hostile feeling between the employed and employers; 6. An organization of employers to resist future efforts of the same kind; 7 and lastly; the disclosure of the alarming prevalence of dangerous and destructive ideas among certain portions of the laboring-classes.

Of this last count it may be remarked that in the inflammatory harangues at public meetings it was constantly proclaimed that capitalists are the deadly enemies of the working-classes; that capital, of right, belongs to the producers who have created it; and the doctrine was avowed by some that, if the strikers could not get their own, the torch should prevent their robbers from enjoying it. Much of this intemperate talk should, no doubt, be credited to the excitement of the time, but it shows both the danger of such excitements and the sort of ideas that are simmering in the minds of many working-people.

As a partial compensation for all these mischiefs, it is hoped that something valuable has been learned from this experience. If it teaches laboring-men that this is not the way to promote their real interests, much will have been gained. The pathway to success is ever through failure, and to have tried a policy and proved its insufficiency is often the necessary preliminary to another and a better policy. That the relations of labor to capital are unsatisfactory, need not be denied; that the laboring-classes are often scantily and unjustly paid, and do not receive an equitable share of the profits resulting from the coöperation of operative and capitalist, is undoubtedly true. And the inequitable working of the present system is, in many cases, very hard to bear. There are evils to be overcome, and wrongs to be righted, but the great problem to be solved, in securing the remedy, is far from easy, and its solution is to be sought in quite another direction from that which has been lately taken. Laborers have a right to demand an advance of wages, to refuse to work if they do not get it, and to combine for the attainment of their end, but they have no right to re-

sort to violence or measures of intimidation to carry their points. So long as strikes are peaceable, they are legitimate means of advancing the interests of labor; to what extent they are *wise*, means, time, and experience, will demonstrate. Yet we do not believe that it is by assuming and fostering enmities and widening the gulf between these two great classes, that the interests of the more numerous party are to be permanently subserved. It is not by measures of coercion or by the fiat of law that there is to be brought about a more equitable distribution of the products of capital and labor than now exists. Only as the laboring-classes become better informed in regard to the conditions of the question they have undertaken to settle—the principles it involves and the laws which govern a healthy social advancement—will they be enabled to cope with capitalists and secure a fairer division of the profits of industry. They must, first of all, accept the spirit of civilization, which is pacific, constructive, controlled by reason, and slowly ameliorating and progressive. Coercive and violent measures, which aim at great and sudden advantages, are sure to prove illusory.

The industrial classes must learn to organize more perfectly, to rely upon moral considerations, to demand only justice, and to wait patiently until by these means their ends can be accomplished. For these ends the resources of education must be invoked. There is a stir throughout all civilization for increased technical education, by which labor shall be made more intelligent and efficient. This is certainly important, but it is not enough. The elements of political economy and of social science ought to be introduced into general education, and until this is effectually done we cannot hope to be exempt from the consequences of the present ignorance upon these subjects.

THE PLACE OF SCIENCE IN THE HIGHER EDUCATION.

We return to this subject because of its extreme importance, and because it is an essential part of our legitimate work. It is not only inevitable that a periodical devoted to the popular interests of science must treat the question of its place in education and the causes which hinder its admission to that place, but this duty is made the more imperative by the fact that the newspaper press is predominantly in the interest of existing usages, and gives wide dissemination to crude and erroneous views upon the question.

The *Christian Union* takes ground upon this subject which we cannot think well considered, and which is certainly out of harmony with its character as an able expositor of the principles of sound reform. It says:

By a singular confusion of ideas, the popular demand for "practical" education in colleges often specifies scientific studies as having peculiarly that character. In reality, while the natural sciences supply to certain classes of workers their main intellectual capital, to professional and business men they have no more of a "practical" value than Latin and Greek. We do not impugn their usefulness as part of a general education, but it does not lie in this direction. On the other hand, there is a class of studies of the highest practical utility to every American citizen, which have been greatly neglected in our higher education—those, namely, which relate to political and social science. We notice with great satisfaction the steps just taken in this direction at Yale. That university has appointed to lectureships on these branches Mr. E. L. Godkin of the *Nation*, and Mr. David A. Wells—both of them eminent examples of the application of thorough intellectual training to practical politics. A new professorship of political and social science has been filled by the appointment of the Rev. W. G. Sumner, one of the ablest among the younger graduates of the college. We trust that these gentlemen will have a space in the curriculum assigned to their de-

partments proportionate to the importance of the subject.

We fail to see the confusion alleged by the writer. There is a definite proposition which he explicitly denies. Educational reformers complain that the higher institutions in which the classical languages predominate give to our professional and business men an education that is not "practical," and they accordingly insist upon the retrenchment of these studies and the substitution of the sciences, that the higher education may become more truly "practical." This is certainly clear enough, and the antagonistic proposition of the writer is equally clear—that for the education of professional and business men the natural sciences are no more "practical" than Greek and Latin. The issue is thus sharply presented. Yet the ground taken by the writer has been long ago, and even ostentatiously, given up by the stanchest defenders of the classics. To the popular indictment that classical studies are not "practical" they have pleaded guilty, but have claimed that this alleged vice is in reality a virtue. The whole literature of that side of the question has been pervaded by a scorn of utility, and a contempt for the "practical." The dead languages have been advocated, not for their ulterior uses, but as mental gymnastics in which discipline of the faculties is the object to be obtained. It has not been denied that the sciences were "practical," but practical ends have themselves been repudiated as low, sordid, and unworthy.

Perhaps, however, the writer in the *Union* may not care what ground has been formerly taken. Is it *true*, then, that for the higher education of professional and business men the natural sciences are no more practical than Greek and Latin? By "practical" in this connection we understand that which bears upon practice, which fits for action. All are agreed that education is a calling out of human powers in preparation for something; and the term "practical," as employed by the friends of reform, is used to designate what the general character of this preparation should be. They maintain that it should have reference to the circumstances, duties, and work of life. Will it be claimed that the knowledge of two languages spoken by nations that have been extinct for many centuries, which were dead long before modern knowledge came into existence, and which have been emptied of their valuable thought over and over again by translation, confers an equal preparation for the responsibilities of practical life with that living knowledge of present things—that acquaintance with the forces and laws of the surrounding world which it is the office of science to impart? Even if the writer gives to the term "practical" as applied to education its narrowest meaning, that of a bare and specific preparation for professional and business pursuits (which is *not* the meaning given to it by educational reformers), his proposition is baseless, for there is not a profession or a business which does not involve scientific principles that must be known if they are to be "practised" intelligently. Merchant, manufacturer, agriculturist, and engineer; physician, lawyer, and clergyman—all deal with phenomena that are regulated by natural laws, and are intimately dependent upon them; and are we still to be told that a knowledge of these laws is of no more practical benefit than to be able to read a couple of antiquated languages?

With such an estimate of the educational value of scientific knowledge, it is not surprising that the writer in the *Union* throws no light upon its proper claim and place in the higher education. He admits that there are studies of the highest practical utility which have been greatly neglected—those, namely, which relate to political and social science—and is pleased that

Yale has taken steps to repair this deficiency. He says, that university has appointed two gentlemen to lectureships upon these subjects, with the following qualifications: they are "both of them eminent examples of the application of thorough intellectual training to practical politics;" and the hope is expressed that a space will be allowed in the curriculum proportionate to the importance of the subjects. We cordially concur with him in this desire, and cannot doubt that advantage will arise from the teachings of the able men selected to take the professorships; but we hold that merely to make a "place" for these studies or to engraft them on the classical stock, or to intrust their exposition to gentlemen whose qualifications are only the application of "thorough intellectual training to practical politics," is a quite inadequate preparation for the work to be done.

Social and political sciences are confessedly the most complex, obscure, and difficult of all the sciences; so much so that it is hardly yet understood what is meant by the terms, even by those who use them most freely. We have looked through the reports of the Social-Science Associations—English and American—for something like a clear definition of what social science is. This question was formally attacked, not long ago, at a convention in Boston, by men whose names are eminent in connection with the subject, but there was the most extraordinary disagreement, and a tacit confession of the impossibility of the task. The proceedings of these bodies abundantly attest this vagueness and conflict of opinion. They mainly consist of philanthropic projects and reformatory schemes for public improvement—plans for repairing the defects of society—which would be better described as social art than social science. With such loose and erroneous notions in regard to the subject itself, we are hardly to expect any clear views of its proper place in education. We have had centuries of that "thorough intellectual training," which it has been the boast of universities to give, applied to "practical politics" without so much as even discovering the existence of a social science. A higher education, which prides itself on the perfection of its mental discipline, and which sacrifices every thing else to this idea, has thrown its graduates by thousands, age after age, into political and public life to very little purpose, so far as the increase of our scientific knowledge of society is concerned; and for the obvious reason that the vaunted mental discipline has not been of a scientific character, and is therefore valueless for great scientific ends. This inquiry is, however, being worked out in a series of articles now appearing in the POPULAR SCIENCE MONTHLY. And it is well here to note that this difficult and important work is being first thoroughly done by a thinker whose intellectual training was not obtained at the university, who knows nothing of Greek and Latin, and has had very little to do with practical politics. His preparation, indeed, is such as the universities would not have afforded, and the chances are high that, if he had submitted himself to their guidance, and had his mind drilled in youth by their methods, and filled with their ideas, the great work that he is now doing would have been impossible for him. His preparation has consisted in the life-long study of science. He has mastered its various departments, and attested this mastery by original discoveries in its physical and biological branches; and, having given his whole life to these studies and obtained a knowledge of them which Mr. Mill has pronounced "encyclopædic," he has the indispensable preparation for the work of extending science in its higher and unexplored applications to social phenomena.

If there be a social science, it is be-

cause there are natural laws of society, laws of social condition, social action, and social change, and because human societies are parts of the general order of Nature; and that science must simply consist in the elucidation and exposition of these laws. So far from being of an isolated nature, which can be considered alone, social science is intimately and vitally dependent upon other sciences, and the proper preparation for it must consist in a knowledge of these, and a thorough discipline in scientific methods of thinking. The student must be steeped in science, as he is now steeped in classics. To thrust social science into the old traditional curriculum—to charge the minds of students with Latin and Greek literature, as a preparation for it—is, therefore, to say the least, irrational. Agreeing with the writer in the *Christian Union* as to the extreme importance of these studies, and the need of giving them a larger place in the collegiate scheme, we go yet further, and demand a reconstruction of the curriculum itself, and an adequate preliminary course of scientific study which shall be tributary to the end proposed.

LITERARY NOTICES.

MICHAEL FARADAY. By I. H. Gladstone, Ph. D., F. R. S. New York: Macmillan & Co.

WHATEVER is truly great has an interest that is inexhaustible. Again and again we return to the mountain, the cataract, the cathedral, the picture, the poem, with an ever-deepening appreciation of their influence over us. And so it is even in a more eminent degree with the grand in human character, for a human life of noble impulse and heroic achievement has also its perennial interest. We read the story as told by the skilful and sympathetic biographer, and then come back to it again fascinated by the majesty and the mystery of a powerful personality. Michael Faraday was a man of this heroic type, great among his countrymen, illustrious in humanity. Prof. Tyndall has given us a vivid portraiture of him as a man of science and a discoverer; Dr. Bence Jones, in two elaborate volumes, has displayed to us his inner life as illustrated in his private correspondence; and now Dr. Gladstone, in the neat little volume before us, has again told the wonderful story in a fresh and fascinating way. Drawing freely upon the works of Professors Tyndall and Jones, adding new information from various sources, among which are his own reminiscences, he has make a book that needed to be made and which is a model of its kind—clear, simple, discriminating, and appreciative. It first gives us the "Story of his Life," next the "Study of his Character," then the "Fruits of his Experience," again, his "Method of Working," and finally the "Value of his Discoveries."

We have no space here to give a sketch of Faraday's life—his humble birth and the little education he got in early boyhood at a common day-school—his first occupation as an errand-boy—his apprenticeship to a book-binder—his thirst for knowledge and how he commenced his scientific education by reading the books that were given him to bind—his passion for experimenting—his application to Sir Humphrey Davy for a chance to devote himself to science—his entrance to the Royal Institution, which was to be the theatre of his career—his rapid ascent to an eminent place among *savants* and philosophers—his rejection of wealth and titles, and his brilliant career as a discoverer, which was crowned by honors showered upon him by the learned societies of all nations—for the account of these things the reader is referred to the pages of Dr. Gladstone's book. But we cannot forbear quoting a few passages illustrative of Dr. Faraday's character. The author says:

As a source of success there stands out also his enthusiasm. A new fact seemed to charge him with an energy that gleamed from his eyes and quivered through his limbs, and, as by induction, charged for the time those in his presence with the same vigor of interest. Plücker, of Bonn, was showing him one day, in the laboratory at Albermarle Street, his experiments on the action of a magnet on the electric discharge in vacuum-tubes. Faraday danced round them; and, as he saw the moving arches of light, he cried, "Oh! to live always in it!" Mr. James Heywood once met him in the thick of a tremendous storm at Eastbourne,

rubbing his hands with delight because he had been fortunate enough to see the lightning strike the church-tower.

This perseverance in a noble strife was another of the grand elements in his success. His tenacity of purpose showed itself equally in little and in great things. Arranging some apparatus one day with a philosophical-instrument maker, he let fall on the floor a small piece of glass: he made several ineffectual attempts to pick it up. "Never mind," said his companion, "it is not worth the trouble." "Well, but, Murray, I don't like to be beaten by any thing that I have once tried to do."

This faithful discharge of duty, this almost intuitive insight into natural phenomena, and this persevering enthusiasm in the pursuit of truth, might alone have secured a great position in the scientific world, but they alone could never have won for him that large inheritance of respect and love. His contemporaries might have gazed upon him with an interest and admiration akin to that with which he watched a thunder-storm; but who feels his affections drawn out toward a mere intellectual Jupiter? We must look deeper into his character to understand this. There is a law well recognized in the science of light and heat, that a body can absorb only the same sort of rays which it is capable of emitting. Just so it is in the moral world. The respect and love of his generation were given to Faraday because his own nature was full of love and respect for others.

Each of these qualities—his respect for and love to others, or, more generally, his reverence and kindliness—deserves careful examination.

Throughout his life, Michael Faraday appeared as though standing in a reverential attitude toward Nature, Man, and God—toward Nature, for he regarded the universe as a vast congeries of facts which would not bend to human theories. Speaking of his own early life, he says: "I was a very lively, imaginative person, and could believe in the 'Arabian Nights' as easily as in the 'Encyclopædia;' but facts were important to me, and saved me. I could trust a fact, and always cross-examined an assertion." He was, indeed, a true disciple of that philosophy which says: "Man, who is the servant and interpreter of Nature, can act and understand no further than he has, either in operation or contemplation, observed of the method and order of Nature." And, verily, Nature admitted her servant into her secret chambers, and showed him marvels to interpret to his fellow-men more wonderful and beautiful than the phantasmagoria of Eastern romance.

His reverence toward Man showed itself in the respect he uniformly paid to others and to himself. Thoroughly genuine and simple-hearted himself, he was wont to credit his fellow-men with high motives and good reasons. This was rather uncomfortable when one was conscious of no such merit, and I, at least, have felt ashamed, in his presence, of the poor, commonplace grounds of my words and actions. To be in his company was, in fact, a moral tonic. As he had learned the difficult art of honoring all men, he was not likely to run after those whom the world counted great. "We must get Garibaldi to come some Friday evening," said a member of the Institution, during the visit of the Italian hero to London. "Well, if Garibaldi thinks he can learn any thing from us, we shall be happy to see him," was Faraday's reply. This nobility of regard not only preserved him from envying the success of other explorers in the same field, but led him heartily to rejoice with them in their discoveries.

HEALTHY HOUSES: A HAND-BOOK OF THE HISTORY, DEFECTS, AND REMEDIES OF DRAINAGE, VENTILATION, AND WARMING. With upward of Three Hundred Illustrations. By William Eassie, C. E.

THIS is an excellent little manual on sanitary science, intended, as the author observes, to be a record of facts—of acquired experiences and published inventions in relation to house-construction. It is both scientific and practical, the science being universal, and the practice English. But, from an hygienic point of view, the subject of house-construction is much the same in given latitudes. Human life and its conditions being everywhere similar wherever the largest number are "to be fed, housed, educated, amused, enriched, and all in the smallest possible space," which is Mr. Eassie's ideal of a dwelling, the same questions must constantly arise, the same dangers are to be avoided, and the same advantages secured. The author has compressed an enormous amount of valuable information on the subject of sanitary construction within very narrow limits, and his book is written in an unusually compressed and pithy style. He gives descriptions of the best contrivances in use for attaining salubrity in all parts of the dwelling, and furnishes the reader with exact estimates of their cost. His book, indeed, is a condensed report upon the present state of art and science in England as applied to the utilities of household arrangement and construction. The following passage, describ-

ing a faulty English residence, illustrates the author's appreciation of the practical detail of his subject:

A residence in which unhealthiness reaches about its maximum may be said to be one which is built on a damp site, with higher ground behind, pouring down its waters against walls without areas—walls innocent of a damp-proof course to arrest the rising wet—and walls, likely enough, also exposed, by insufficient thickness, to driving rains. It may be in the neighborhood of low-lying fields, undug, unditched, undrained, or with the tiles long since choked up. The rooms throughout are low, with a haphazard ventilation, insufficiently furnished with windows, and with perhaps too many doors. The main staircase is without a lantern-vent, or the wall there is pierced by a window not sufficiently high to empty the gasometer overhead. As for the back-stairs, the basement-smells climb them *en route* for the dormitories. The chimney-flues are also badly constructed, and a smoky atmosphere is all but constant. Overcrowding lends its quota of evils—as press-beds in every available corner testify. The drain-pipes are injudiciously laid inside instead of outside the basement, with leaky joints, owing to indifferent luting, and with pipes broken where they pass through the walls, owing to continuous settlement. A foul soakage of the soil around the unpuddled pipes speedily follows. The lead-work is also defective, dishonestly executed with thinnest material, badly junctioned to the drains; or, if once properly performed, the maintenance of that state of things is neglected from ignorance or parsimony. The water-pipes, too, are all built in the brick-work, or buried deep in plaster, a burst pipe soon causing the walls to resemble a huge sheet of wet blotting-paper. As for the sinks, they are far too numerous, and made to perform improper services. The scullery-traps have long ago lost their gratings, and are filled up with grease or other refuse. Up-stairs the waste-pipe of the lavatory and of the bath are connected direct with the sewer. There is, moreover, only one cistern for the multitudinous necessities of a family. The closets, supplied from this same cistern, stand directly in the passage, and have only one door; the apparatus is faulty, and the hidden soil-pipe is somewhere imperfect. Ventilation of the drains there was originally none, and none is contemplated; the accumulated gases, therefore, take the water-trap by storm, and invade the atmosphere of the house. Even the flushing of the too flatly laid house-drains is unattended to, or left to the periodical downfall of rain through the rain-water pipes, which only serves to stir up the nuisances, not carry them resistlessly away.

THE LENS: A QUARTERLY JOURNAL OF MICROSCOPY AND THE ALLIED NATURAL SCIENCES. Edited by S. A. Briggs, Chicago.

THIS elegant periodical, a credit alike to science and to Chicago, has now reached its third number, which comes filled with interesting and valuable articles. It is published by the State Microscopical Society of Illinois—a significant fact, as indicating an extending taste for nice and critical observation. The use of the microscope combines elegant and refined recreation with serious and solid scientific work, and we are glad to see these evidences of its increasing appreciation. For a long time the microscope was but a plaything, and the share it was to take in the development of knowledge was little suspected. Even so late as 1839, according to Mr. Lewes, Magendie denied that it could be of any use in physiology. But, since then, it may almost be said that it has given us a new physiology, while it has become perfectly indispensable in intelligent medical practice, and is in constant requisition in nearly every department of science. It is important, therefore, that we should have a periodical especially devoted to the interests of the instrument, its results, and the numerous subjects which are dependent upon its application. *The Lens* promises to supply this need. Its papers are varied and able, and the illustrations excellent. We cordially wish it the success it deserves.

DR. H. CHARLTON BASTIAN'S long-expected work, "The Beginnings of Life," is now completed, and will be speedily published in two volumes. Dr. Bastian is the leading "representative of the doctrine" popularly known as spontaneous generation, and this work will contain the results of his extensive experimental investigations concerning it. His treatise, however, goes much further than this, and is, in fact, a broad discussion of philosophical biology—a cyclopædia of facts, theories, processes, and conclusions respecting the origin of the simpler forms of life. He works the subject from the *a priori* and rational point of view, as well as from that

of positive and rigorous experiment. He claims to have established directly, by observations that may be verified, that matter passes from the non-living to the living state, and he aims furthermore to show that this fact is consonant with the whole scheme of Nature's working. His preliminary chapters on the correlation of the vital and physical forces, on the nature and theories of life, on organized and organizable matter, on the relations of the animal, vegetable, and mineral kingdoms, and on cell-phenomena and cell-doctrines, form the clearest and most readable exposition of these subjects that we have yet seen, and they have a value quite independent of the special inquiry to which they are an introduction.

GEOLOGICAL SURVEY OF OHIO. Report of Progress in 1870, by J. S. Newberry, Chief Geologist, including Reports by the Assistant Geologists, Chemists, and Local Assistants. (Columbus: Nevin & Myers, State Printers, 1871, pp. 568.)

THE labors of Prof. Newberry and his colleagues during the year 1870 have resulted in the accumulation of a great many details relating chiefly to the structure of that portion of the great Appalachian coal-field which extends over a considerable part of Ohio. Without the aid of a good map it is somewhat difficult to follow the descriptions given in this report, the numerous local references and details having a tendency to bewilder the reader. This, however, is unavoidable under the circumstances; and those who desire to obtain a full and clear conception of the geological structure of Ohio will have to wait the completion of the map and final report promised by Dr. Newberry, the present volume not pretending to be more than its title implies. Nevertheless, it contains a very large and varied amount of information, which will, no doubt, be duly appreciated by those for whom it has been prepared. Especially noteworthy are the numerous illustrative sections of Carboniferous strata, and analyses of coals, iron-stones, fire-clays, and soils, as also two ably-written sketches, "On the Present State of the Manufacture of Iron in Great Britain," and "On the State of the Steel Industry," both of which will repay perusal by those who are interested in these matters.

Scattered through the purely geological portion of the report are many points of interest, which arrest attention as one glances over the pages. Thus we are told that "at Zaleski, in mining the Nelsonville coal, a fine bowlder of gray quartzite was found half embedded in the coal, and the other half in the overlying shale. The quartzite is very hard, and the bowlder was rounded and worn by friction before it came to the coal." It measured 17 in. by 12 in., and had adhering to it in places bits of coal and black slate which showed a slicken-sided surface. The stone appeared to have settled into the coal when the latter was in a soft state. Prof. Newberry speculates with diffidence on the possibility of the bowlder having been "brought down by river-ice from some higher and colder part of the old continent, which was skirted by the coal-producing lowlands." In connection with this, it is somewhat interesting to find that a local deposit of quartz conglomerate occurs here and there underneath and skirting the coal-strata, and is believed by Dr. Newberry to represent an old beach of the period. From some such gravel and shingle deposit the bowlder may have been transported, but whether by means of ice, water-plant, or land-plant, who shall tell?

Another exceedingly interesting and readable portion of the Report is the "Agricultural Survey," by Mr. J. H. Klippart, in which the writer discusses, among other subjects (such as prairies, forests, etc.), the origin of the soils in certain districts of the State. Those geologists who believe in the former existence, during the Glacial epoch, of mild interglacial periods, will find much here to support their opinion. We are told that the succession of the drift-materials, beginning with the oldest, is as follows:

a. Glacial drift.
b. Erie clays.
c. Forest-bed.
d. Iceberg-drift.
e. Alluvium.
f. Peat, calcareous tufa, shell-marl.

The oldest deposit is believed to be the product of land-ice, and the presence of the Erie clays betokens that, after the disap-

pearance of the great glaciers, wide sheets of fresh water overspread some districts of the State. The forest-bed (consisting of roots, trunks, branches, and leaves of such trees as sycamore, beech, hickory, and red cedar) shows that by-and-by the fresh-water basins were in some places filled up, and the new soil covered with an abundant forest-growth. After this came a period of depression, when great deposits of gravel and sand gathered over the surface of the drowned land, and large bowlders and erratics were floated by ice from the north.

These and other matters of interest and importance will, no doubt, be fully treated of in the final report, which is to consist of four volumes, the first two being devoted to the geology and paleontology of the State, the third to its economic geology, and the fourth to its agriculture, botany, and zoology. A large collection of fossils has been made, many species being new to science. It is to be hoped that the good people of Ohio will not grudge the money that will be required for the adequate representation and description of these remains, but that, when published, the final report will be found in every way as complete as those admirable works which have been issued by other States of the Union. Prof. Newberry seems to have little doubt that it will be so, for he thinks that the value and significance of fossils are coming to be generally appreciated. "There are, however," he says, "yet some intelligent men, even editors and members of Legislatures, who cherish the notion that there is nothing which has any value in this world but that thing which has a dollar in it, and that so plainly visible as to be seen by them. Such men, to quote the language of one of them, 'don't care a row of pins for your clams and salamanders, but want something practical.'" This "practical" man must surely have been related to that colonial official who is said to have objected strongly to the expense of "engraved portraits of extinct bugs and beetles," as he irreverently styled certain Silurian fossils. But the day of such wiseacres has gone past, and it may be confidently expected that Dr. Newberry and his colleagues will have no difficulty in getting the necessary funds voted for the completion of their important survey.—*Nature.*

MISCELLANY.

Experiments on the Solar Spectrum.—Some experiments recently published by Dr. John W. Draper, of the New York University, on the heat of different portions of the solar spectrum, will change, in several important particulars, the views hitherto held on that subject.

Until now, it has been supposed that the heat of the spectrum is greatest below the red region, and that it gradually declines as the thermometer passes through the orange, yellow, green, blue, indigo, and violet, successively.

Dr. Draper shows that, while this is true as a matter of observation, the general conclusion drawn from it is altogether incorrect. In the prismatic spectrum the red and less refrangible colors are compressed together, the violet and more refrangible are expanded. This distortion is necessarily due to the action of the prism itself. But, in the diffractive spectrum, formed by lines drawn with the point of a diamond on glass, the arrangement of the colors is altogether different; they are placed according to their wave-lengths.

Dr. Draper proves that, for the correct solution of this problem of the distribution of heat, the visible spectrum *alone* should be employed, the ultra-red and ultra-violet invisible rays being removed. He next finds the centre of the visible spectrum, proving that it is a little beyond the sodium-line D. He then, by the aid of a silver mirror, collects all the less refrangible rays up to this centre into one focus, and all the more refrangible rays from this centre into another focus, and measures the heat of each. On the received view, the former of these foci should contain nearly all the heat, the latter little or none. In several hundred experiments in which exact measures have been made, it turns out that the heat is the same in both.

From this, some very remarkable results follow. Among them we may mention, that all the rays of the spectrum, irrespective of their color or wave-length, have equal heating-power; and that, in fact, the heat manifested in any part of the spectrum is due to the stoppage of the motion of the

rays—their extinction. It is the transmutation of motion into heat.

Extensive Conglomerate Formation on Long Island.—A short distance northeast of the village of Farmingdale, on Long Island, there is an extensive formation of ferruginous conglomerate, of much geological interest, and considerable economic value. It is found in the level sandy tract which extends from near Farmingdale to some fifty miles eastward. Over this tract stones larger than good-sized pebbles are exceedingly scarce. In digging wells, it is found that pebbles and sand occur in layers, at all depths yet penetrated. The conglomerate consists simply of these sandy and gravelly layers, hardened into a compact, brown-colored mass, which can be blasted out in blocks, and which answer a very good purpose for the foundations of buildings. The thickness of the formation is thought to be about 12 feet. The rock appears to grow harder on exposure, and some specimens give out a clear, ringing sound when struck with a hammer. The sand-grains which enter into its composition are of a brown color throughout, while the pebbles are only colored externally. Compounds of iron are associated with the mass, and the waters of the district are also largely ferruginous, whence it is suggested that the formation may be due to a kind of cementing action exerted by the iron, left by the waters that have percolated through the sands.

Were the Ancient Italians Cannibals?—A somewhat remarkable discovery of human and animal remains is announced by Prof. Capellini, of Bologna, in a grotto in the island of Palmeria, the access to which is difficult and dangerous. Here he caused excavations to be made, and the result was the discovery of numerous flint and stone implements, the workmanship of which showed that they belonged to the earliest period of the stone age. Besides these wrought implements and various other objects brought into the cavern by its human occupants, he found a considerable quantity of bones of animals mingled with bones of human beings. The condition of these latter bones, he says, "would justify the inference that the grotto had been inhabited by anthropophagi, and that the Italians of that epoch were cannibals, like their contemporaries in Belgium, France, and Denmark."

"Among the human bones were found those of women, and part of the jawbone of a child some seven or eight years of age. Some of these bones were entire, others were partially calcined. In the centre of the cave it was possible to discern traces of a fireplace. Prof. Capellini says: 'Whoever has busied himself in prehistoric researches, whoever has read Spring's excellent work on the Chauvaux cavern in Belgium, and the writings of other authors on the subject of the caverns in France, will not hesitate to admit that the discoveries in the island of Palmeria prove that the Italians were, as I have said, man-eaters. For the present it will be sufficient for me to direct the attention of naturalists to the subject. The Cyclopians spoken of in the fable were probably these cannibals.'"

Coal-Lands of the Rocky Mountains.—According to "Hayden's Reports," which abound with useful information concerning the new Territories of the West, the coal-deposits of the Rocky Mountains far exceed any thing that had been hitherto suspected. Early travellers, as Lewis and Clarke, in 1800; Colonel Fremont, in 1842; Captain Stansbury, in his visit to Salt Lake, and others, had reported outcrops of coal on the slopes of these mountains, but probably none were aware either of its abundance, or the extent of country over which it is spread. Coal is found at different points in the Rocky-Mountain region over an area of some 250,000 square miles in extent, in strata which in some places are from five to thirty-five feet in thickness. Outcrops have been followed on the east flank of the mountains for more than 500 miles north and south; and if, as Hayden suggests, these are fragments of one great basin, broken only by mountain upheavals, or covered by later deposits, then the distance from east to west may be as much as 500 miles, or from the "Black Hills" to "Weber Cañon." If the coal-strata were ever continuous over this vast area, the subsequent formation of mountains and valleys would leave them broken and disconnected, as they are now found to be.

Yet it is the opinion of explorers, that here, as elsewhere, the deposits are in minor basins, united perhaps in places, but, as a rule, constituting separate beds, over a vast area of depression. Hayden says there is good reason to suppose that this area "extended northward far into Canada, and southward with the Cordilleras;" a supposition that, if true, would give an extent of coal-lands, in this section of the continent, much greater even than that just mentioned.

The Rocky-Mountain deposits are regarded as belonging to a much later geological age than those of Pennsylvania or of Rhode Island. While the latter belong to the Carboniferous age, the former are found chiefly in the upper Cretaceous or Chalk period, or in the so-called Tertiary; which brings the period of the Western coals nearly down to the latest geological ages.

The value of the Rocky-Mountain coals is unquestioned. From various analyses, it appears, that their volatile constituents reach about 38 per cent., while the amount of fixed carbon is estimated at about 50 per cent. Pennsylvania anthracite is much richer in fixed carbon, but the coals of Iowa, as well as some Scotch and English varieties, are considerably poorer in this respect. But, apart from their fixed value as sources of heat, the coals of this region derive an additional importance that can hardly be over-estimated, from their geographical position. In a country without timber, and far removed from other sources of fuel, they supply the first requirement for the development of its resources, and have already become the object of an extensive and thriving industry.

Lessons from a Brick.—An Austrian *savant* has discovered, by means of a microscope, in a brick taken from the pyramid of Dashour, many interesting particulars connected with the life of the ancient Egyptians. The brick itself is made of mud of the Nile, chopped straw, and sand, thus confirming what the Bible and Herodotus had handed down to us as the Egyptian method of brick-making. Besides these materials, the microscope has brought other things to light—the *débris* of river-shells, of fish, and of insects, seeds of wild and cultivated flowers, corn and barley, the field-pea, and the common flax, cultivated probably both for food and textile purposes, and the radish, with many others known to science. There were also manufactured products, such as fragments of tiles and pottery, and even small pieces of string made of flax and sheep's wool.

Zoology of the Galapagos.—A correspondent of the *Tribune*, accompanying the Hassler expedition, gives an interesting account of the animals observed in the Galapagos Islands. He says:

Over 50 different kinds of fishes were obtained, and of these over three-fourths are peculiar to the Galapagos. Of the Galapos, from which the islands are named, and in which they once so richly abounded, we only got a few specimens, and those very small compared with those of olden time. They have been so eagerly hunted for their flesh that they have been driven from the more accessible places, and stand a good chance of being altogether exterminated. Their brethren in the sea, the tortuga or sea-turtle, we saw in abundance, and got some very fine specimens. There are, as is tolerably well known, two other reptiles for which this archipelago is famous—two lizards, of a genus not found elsewhere, and very peculiar in their habits. The Spaniards called them iguanas, from their resemblance to that reptile in the West Indies and Central America. But they differ so much from their American cousin that they ought to have a name of their own, and if the scientific Amblyrhynchus looks too formidable, let us translate it and call the creature a Bluntnose. On Charles Island we found abundance of the crested Bluntnose climbing with great agility over the rocks near Black Beach. The creature is about 30 inches long, nearly black, the old males having a deep-red hue on the sides. It swims with great ease by its flat tail, and uses its long fingers and long nails for scrambling on the rocks, holding them, while swimming, close to the body. There is not a trace of web-footedness about them, and they make no use of the feet in swimming. They live on sea-weeds from the rocks in deep water, and their expression is mild and herbivorous, with a little clear, innocent eye. I was prepared for something hideous, and was agreeably disappointed. In another respect our experience differed from Darwin's, for we sometimes had no difficulty in frightening them into the water, and they came fearlessly swimming about the Hassler as she lay in Tagus Cove. These crested Bluntnoses we found upon all the islands. The slightly-crested Bluntnose we found only on Albemarle and Indefatigable.

Its scientific name might mislead one, for its head is just as much crested as its aquatic brother's. The only differences between them, apparent at first sight, are these: The terrestrial animal is somewhat stouter, his nose is longer, his eye brighter, his tail less flattened and less crested, and his color is a dusky orange, deepening into brown on the hind-quarters. His habits of life are very different, as he does not go near the sea, but lives upon land-plants, and makes a burrow for himself in the sand and among the fragments of lava. He spreads his hind-legs flat on the ground, raises his chest to the height of his fore-legs, and then nods and winks at you in a very odd way. It looked to me very much like swallowing, and I thought it possible that the creature, with his head in that position, swallowed air like a toad, as a means of breathing—swallowing into the lungs, not into the stomach.

One of our most interesting adventures was landing in a little bay full of seals, so tame, or rather so little afraid of men, that we could tramp past groups of sleepers on the beach without awakening half of them, and without apparently frightening half of those that we did awake. They seemed to be fond of crawling under bushes just above high-water mark, and sleeping, two or three in a place, huddled close together. Under one bush lay a mother and her two cubs, so fearless that one of our officers held a piece of cracker to the old one, and she smelled it in his fingers as fearlessly as if she had been a pet dog. The cubs quarrelled with each other as to which should cuddle nearest the mother, and they all three snarled and snapped at the flies in the manner of a sleepy dog, and all this while a party of ladies and gentlemen, creatures as large as the seals, and which the seals could scarce have seen before, stood looking on within touching distance. These seals had much more length of arm, and used their arms more in the manner of a quadruped, than I had supposed any seal could do. I saw them walk on the beach with the whole chest clear of the ground, and even jump upon the sand. Their favorite gymnastic exercise, however, was to lie upon their backs and roll, in the manner of a horse. The tameness of these seals and of many of the land-birds was very surprising; the Bluntnoses were more shy than we had expected. I repeatedly put my fingers within half an inch of little yellow-birds and phœbes, and within six inches of mocking-birds. On James Island the birds were so numerous and so tame that, while I was trying the experiment whether whistling to a yellow-bird would divert his attention so much as to make him allow me to touch him, six other birds—including two mocking-birds—came up and alighted on twigs within two yards of the yellow-bird to see what was going on between us. As for the flies, their tameness and pertinacity of adhesion, at the Galapagos, goes far beyond all travellers' accounts. I knew a good house-keeper in New England who affirmed that house-flies could not be driven out of a room unless you struck and killed one or two, in order to show the others that you were in earnest. You cannot drive the Galapagos flies from you even with that expedient. The birds and seals are not frightened by being stoned or shot; they don't know what stones and guns mean, and the flies are not frightened or discouraged by having any amount of their comrades killed. When a boat was coming off-shore, the usual occupation, in order to prevent carrying the nuisances on ship, was for everybody to be picking the flies off themselves (almost as they would burrs), killing them, and throwing them into the water, from the time of leaving the beach to the arrival on the deck of the ship; and the last fly slaughtered before you go into the cabin is no more afraid of you than the first one you slew at the beach. They are not all biting flies; we have escaped trouble from mosquitoes and biting flies during the whole voyage, but they are crawling, tickling, adhesive, tantalizing creatures. It was pleasant to find here at the Galapagos a species of penguin, smaller and more sober in dress than our old friends of the Straits of Magellan, but with the same winning, cunning manners that made the birds in the Straits such favorites with our party. And, while speaking of the birds of these islands, I would not forget the splendid flamingoes, six feet high, of which we got many fine specimens. They sailed about in parties of 12 or 20 birds together, making long lines of scarlet flame floating through the air. We tried their flesh on the table, and found it the most delicious game, fully equal to the canvas-back, as it seemed to us. The archipelago offers at present a fine opportunity for a naturalist, who desires to make a residence here for several years, and thoroughly explore their structure, and their productions, to throw a strong light upon the great modern question of the origin of species, and the doctrines of evolution. Younger than Juan Fernandez, purely volcanic, bringing no seeds with them from the bottom of the sea, not having had time to alter and amend species introduced from the main-land, how did these islands come in possession of their peculiarly-organized beings—their Bluntnoses, for example? This was the question constantly recurring to me during my visit to the Galapagos, as it had been at Juan Fernandez. Prof. Agassiz gave us a little talk one day on our way to Panama, and discussed the same point. Expressing his warm admiration for Darwin's moral and intellectual character, and earlier scientific labors, he said that he considered

his present influence on science very pernicious as favoring the habit of "filling up the wide gaps of knowledge by inaccurate and superficial hypotheses." What we need, in order to extend our knowledge of the origin of species, is not hypothesis and speculation, but a careful collation of facts, and a careful extension of our observation of facts. The hypothesis that the differences of species were produced by variations taking place in unlimited, in indefinitely long periods of time, is, at all events, strongly negatived by this occurrence of such marked peculiarities of difference from the surrounding world, in an archipelago that belongs wholly to the present geological epoch, and has not existed an indefinite time.

The Bore of cutting Leaves.—A correspondent of the *Scientific American* thus complains to its managers: "*You do not cut your paper;* you compel us, the 50,000, each to cut his own! You have this day robbed me of five minutes precious time in cutting your paper, and the 50,000 each of five minutes! This would make about 520 days of the popular eight-hour kind. Suppose it reached a year or half a year of our most inestimable time; by machinery you could cut the whole edition for $25. Can you excuse yourself? Can all the slovenly publishers of books, periodicals, and newspapers furnish any sort of apology for this wasting of priceless time, amounting to some hundreds of times your own culpability? Why, *Harper's Monthly* has just cost me thirteen minutes, worth to me twice the price of the magazine! What! 100 years or 500 years of human labor wasted weekly in cutting the leaves of your paper, when a few dollars' worth of work by machinery would do it greatly better, and keep your papers and books neat, genteel, and durable! Shame on your whole fraternity!"

Curious Effects of a Brain-Injury.—The recent legal contest over the will of Davis B. Lawler, of Cincinnati, involved many interesting medical and psychological questions. Mr. Lawler died at eighty-two, without issue, leaving an estate valued at $500,000. The question arose concerning his mental state at the time when certain codicils were added to his will, which gave the bulk of his property to the German relatives of his deceased wife.

In October, 1867, nearly two years before his death, Mr. Lawler had a severe fall and concussion of the brain, which was followed by loss of memory of written language, and the codicils in question were made about a month after the accident. His physician, who saw him first six months after the fall, says that he ascertained definitely on his first visit that Mr. Lawler could see printed characters, but that they conveyed no ideas to his mind. The large head-lines of the newspaper, the *Cincinnati Gazette*, he could not read, though he saw them perfectly. He could write his name, and yet could not tell whether what he had written was or was not his name. He could write directions about his business, but could not read the writing though it was plain enough to others. The sight of written or printed characters failed to be converted into ideas, while his power to make them seemed to imply the possession of such ideas. But such writing as he did was shown to have been done automatically. It is well known that many acts, at first acquired with great labor, by endless repetition come to be performed without will and even without consciousness. Piano-playing, dressing, winding a watch, are acts of this nature, and signing one's name may be classed with them. Herbert Spencer says: "The actions we call rational are, by long-continued repetition, rendered automatic and instinctive." He further says: "In short, many, if not most of our daily actions (actions every step of which was originally preceded by a consciousness of consequences, and was therefore rational), have, by perpetual repetition, been rendered more or less automatic. The requisite impressions being made on us, the appropriate movements follow without memory, reason, or volition coming into play." Maudsley holds that, "when an idea or mental state has been completely organized, it is revived without consciousness and takes its part automatically in our mental operations, just as an habitual movement does in our bodily activity." And again: "As it is with memory, so it is with volition, which is a physiological function of the supreme centres, and which, like memory, becomes more unconscious and automatic the more completely it is organized by repeated practice."

After his death, there was found in the brain of Mr. Lawler a globular calcareous mass half an inch in transverse diameter, so wedged into its substance as to obstruct the backward flow of the blood. There were indications that this mass had occupied a different position, and was dislodged at the time of his fall. This case confirms the growing opinion that the faculty of language is associated with the left hemisphere of the brain, and demonstrates, as far as one case can, that the posterior lobe takes part in the operations of speech and written language.

Ascent of Mount Seward.—This mountain is, with the numerous lesser peaks connected with it, the most westerly of the Adirondack range in New York. The ascent in company with a guide has recently been made, and its barometrical measurement taken by Verplanck Colvin, Esq. The ascent took two days and a part of a third. The barometric observations were laid before Prof. Hough, of the Dudley Observatory, who made the computations, and gave as the result an altitude of 4,462 feet. Mr. Colvin speaks of the wanton waste by fire of the woods, and the consequent diminution of the rivers, and recommends to the State government the creation of an *Adirondack park*, or *timber preserve*, suggesting that the officers necessary for its care might be supported by a *per-capita* tax upon sportsmen, artists, and tourists — a tax which he says they would willingly pay if the game should be protected from unlawful slaughter, and the grand primeval forest be saved from ruthless desolation.

A Four-legged Fish.—The members of the Australian Eclipse Expedition, if they were unsuccessful in the primary object of their voyage, saw some strange things along the shores to the north of the great Continent of Australia. Mr. Foord tells a wonderful story, "amply attested by witnesses," of a fish with four hands. This extraordinary creature was found crawling on a piece of coral dredged up from the bottom of the sea. "The body was that of a fish," says Mr. Foord, before the Royal Society on January 22d, "but, wonderful to relate, it had in the place of fins four legs, terminated by what you might call hands, by means of which it made its way rapidly over the coral reef. When placed on the skylight of the steamer, the fish stood up on its legs, a sight to behold. It was small, and something like a lizard, but with the body of a fish." It is to be hoped that a full and scientific description of this latest marvel of deep-sea dredging may soon be published, as the specimen appears to have been brought back to Melbourne. Mr. White, too, of the same expedition, tells strange tales about the rats. "The little island," he said, "upon which we pitched our tent was overrun with them, and what was most extraordinary, they were of every color, from black to yellow, and some tortoise-shell."—*Nature.*

Fungi in Cow's-Milk.—On this subject, Prof. Law, of Cornell University, makes a communication to *The Lens* for July. He says the presence of living organisms in milk has been recognized by various observers. In milk of an abnormally blue color, cryptogams and swarms of infusoria have been noticed, and kindred objects have been seen in milk of a yellow and greenish tint. Dr. Percy's "Report to the New York Academy of Medicine, in 1858, 'On Swill Milk,' shows the presence of spores in such milk when drawn, and the growth of mycelium within twenty-four hours thereafter, though the liquid had stood in a well-corked bottle in the interval. This report shows, further, the tendency of such milk to induce severe and even fatal disorders of the digestive organs of infants, fed upon it exclusively in its fresh condition." Prof. Law examined some specimens of milk, two of which, after twelve hours' exposure, being "placed under the microscope, showed an abnormal adhesiveness of the oil-globules, which had accumulated in dense masses instead of remaining apart as in healthy milk. Intermixed with the globules were dark-colored, spherical bodies of a much larger size, 'spores,' and filaments. Upon examination of the water drunk by the cows, it was found to contain numerous spores of low forms of vegetable life. The cows yielding the morbid milk appeared in health so far as appetite, rumination, pulse, breathing, and state of skin were con-

erned, but the temperature was higher than usual, and, on a microscopical examination of the blood, it was found to contain certain ovoid bodies of at least double the size of the ordinary blood-globules. Upon withholding the water, the impurity of the milk at once disappeared." Prof. Law says: "The chain of evidence now appeared complete. The water contained vegetable spores, which developed into a luxuriant growth of mycelium when allowed to stand, or when added to milk of known purity. The presence of similar germs in the blood was demonstrated, by microscopical examination, by the further development of the cryptogam when the blood was allowed to stand, and by the appearance of the same product in milk to which a drop of this blood had been added. The constitutional effect of its presence was slight, being manifested by a rise of temperature not exceeding 2° Fahr. The germs in question were present in the milk, and grew with great rapidity in this medium. Lastly, the disuse of the contaminated water and the administration of sulphites put an end to the affection."

Preservation of Meat.—Of the vacuum-process for the preservation of meats the *Food Journal* says:

Taking the various methods as a whole, there seems to be as yet nothing better than the vacuum-process, and it is to the results of our examination of a set of samples of meat preserved by a new modification of this plan to which we desire to direct attention. These specimens have been transmitted to us by Mr. Richard Jones, and were preserved under his vacuum-method by Messrs. Forbes & Co., of London and Aberdeen. By Mr. Jones's process, the meat is put into tins and entirely soldered up, except a small tube, which is about the size of a quill, and is soldered into the top of the tin. This tube is placed in connection with a vacuum-chamber, and the air exhausted. The cooking is then commenced, and, without entering into details, we have simply to say the principle involved is, the production of a vacuum before beginning to cook, and the maintaining of the same during the time that the operation is in progress. The special feature claimed for the system is, that "poultry, game, fish, and whole joints of beef and mutton, can be as readily preserved with as without bone—so obviating the hitherto unsatisfactory appearance of preserved meat." Having thus given the *rationale* of the process, we will proceed to the results of the examination of samples.

No. 1 was a roasted sirloin of beef preserved entire. Before opening the package, the tin was observed to have the battered appearance produced by the external pressure of the air, which is always indicative of a perfect vacuum in such tins, and without which no package of preserved meat should ever find a purchaser. On opening, the meat was found to be devoid of the usual shrivelled appearance, and, in fact, presented the characteristics of a joint of meat cooked the day before, and served cold in any ordinary household. Upon cutting into the joint there was no appearance of overcooking and stringiness; it came off in good slices, and was even somewhat ruddy in the centre. It was remarked by our friends who were present at the trial, that the flavor was not at all like the common tinned beef. A portion from the inner part of the joint was cut off for analysis, with the following result:

Water	69.837
Muscular fibre, coagulated albumen, etc.	17.658
Soluble organic salts	2.790
Fat	6.710
Mineral matter	3.510
	100.000

No. 2 was a partridge roasted whole, which presented no trace of a shrivelled or discolored appearance, and stood carving in the ordinary way without tearing into shreds. The flavor was exceedingly fresh and agreeable; the only objection made to it by some of the party was, that it was not sufficiently "high" for their palates.

No. 3 was a section of cod boiled in one piece. This was an exceedingly happy specimen of food preservation. It was so firm in consistence, and so perfect in flavor, that no one would have imagined that it had not been cooked the same morning. It possessed, as one of the company remarked, that peculiar liveliness of flavor which cold fish only retains for a limited period after cooking.

It was not thought necessary to submit either the game or fish to analysis.

Looking to the results of our experiments, we cannot but think that the method of preservation in tins has at last reached perfection in this process, for the development of which we were informed that a company has recently been formed with every prospect of success. When it gets into working-order, there is little doubt but that this meat will head the market until such time as some happy inventors can produce a reliable plan of importing raw meat from our colonies in a sound state.

Scientific Associations.—The twenty-first annual meeting of the American Association for the Advancement of Science will be held

at Dubuque, Iowa, commencing Wednesday, August 21st, at 10 o'clock A. M. On the evening of the same day a formal reception will be extended to the Association by United States Senator Wm. B. Allison, of the reception committee; after a response from the Association, Prof. Asa Gray, retiring president, will deliver his address, and give up the chair to his successor, Dr. J. Lawrence Smith. The British Association for the Advancement of Science will convene this year at Brighton; the first general meeting is appointed for August 14th, at 8 o'clock P. M., when Prof. Sir William Thomson, F. R. S., will resign the chair, and Dr. W. B. Carpenter, F. R. S., will assume the presidency, and deliver an address. The forty-fifth annual session of the German Society of Naturalists and Physicians will be held in Leipsic, commencing Monday, August 12th, and ending Sunday, August 18th.

Providence in Physical Affairs.—The Archbishop of York lately stated, at a meeting of the supporters of the Palestine Exploration Fund, that the progress of the human mind is from vagueness toward precision. In conformity with this tendency, it has been proposed to arrive at more precise ideas in regard to the efficacy of prayer in affecting the course of physical events. An anonymous letter, proposing a plan by which this may be done, was sent to Prof. Tyndall, who approved the suggestion, and forwarded the communication to the editor of the *Contemporary Review*, in which it has just been published.

The writer states that prayers are regularly offered by the Church, designed to secure preservation from pestilence, famine, and battles, the fertility of the soil, and weather suitable for the growth and preservation of vegetable products, for the protection of all that are in danger, and for the preservation of travellers and of sick persons. He proposes to test the efficacy of this influence, and to determine its degree, by a grand experiment, and selects the case of "sick persons" as best suited for his purpose. His plan is thus stated:

The following appears to me to indicate the manner of conducting the inquiry: it should be pursued on a system somewhat analogous to that which is pursued by the Faculty, when a question arises as to the value of any particular mode of treating disease. For example: a new remedy has been proposed, or is said, on high authority, to be efficacious, and, as authority does not suffice in medicine, further than to recommend a given course, and never to prescribe it, the remedy is carefully tested. Usually a hospital or a ward is assigned for the purpose. All the patients suffering from the disease to be treated are, during a certain period, divided into two classes, and all are subjected, as far as possible, to the same conditions, that single one of treatment alone excepted. The ages, sexes, and many other particulars of the patients, are taken into account, and duly noted. The one class is treated by the old system, and the other by the new remedy. When a very large number—for in large numbers only is there truth—has been thus dealt with, the results are compared, and the value of the remedy can be definitely expressed; that is, its influence above or below that of the old treatment, as the case may be, will appear in the percentage of recovery, or of other results.

Now, for the purpose of our inquiry, I do not propose to ask that one single child of man should be deprived of his participation in all that belongs to him of this vast influence. But I ask that one single ward or hospital, under the care of first-rate physicians and surgeons, containing certain numbers of patients afflicted with those diseases which have been best studied, and of which the mortality-rates are best known, whether the diseases are those which are treated by medical or by surgical remedies, should be, during a period of not less, say, than three or five years, made the object of special prayer by the whole body of the faithful, and that, at the end of that time, the mortality-rates should be compared with the past rates, and also with that of other leading hospitals, similarly well managed, during the same period. Granting that time is given, and numbers are sufficiently large, so as to insure a minimum of error from accidental disturbing causes, the experiment will be exhaustive and complete.

Alcoholic Hallucinations.—Dr. Magnan has been investigating the psychical and physiological effects of alcoholism upon the lower animals, and has described the symptoms of hallucination that followed in certain cases of prolonged alcoholic action. He had drugged certain ill-fated dogs for some time with liberal doses, and from the fifteenth day to the end of the experiment the following is what he observed:

One of the dogs remained almost unaffected by the protracted action of alcohol;

he became intoxicated every day, but, once the drunkenness had disappeared, he resumed his usual habits; the other four, on the contrary, exhibited a very remarkable nervous susceptibility. They became restless—listened; the slightest noise caused them to start, whenever the door opened they hastened to cower in the most obscure corner of the hall, leaving in their way a trail of urine; they paid no attention to petting; when one came near them, they bit; if one threatened to strike them, they uttered piercing cries. A short time afterward, hallucinations occurred in two of them. As if pursued by an enemy, they barked violently, they ran wildly in every direction, the head turned back, and biting in the air. Whenever one entered, they crowded against the wall, moaning, crying, trembling in all their limbs. In the middle of the night they began sometimes to howl loudly, to utter doleful cries, and stopped only when one went in with the light.

These attacks of delirium were transient, and occurred regularly toward the end of the state of drunkenness. One of the dogs had hallucinations of a cheerful character, under the immediate influence of alcohol; he appeared affectionate whenever he began to stumble; later, on the contrary, he was indifferent—or, rather, he growled and bit.

These hallucinations, of frequent occurrence during two months of the experiment, became afterward rarer, probably on account of the ingestion of less alcohol.

The author gives the following indications of the stages of hallucination in cases of delirium tremens among men: In the first degree the patient believes he hears abusive language, provocations; he sees thieves, armed persons, animals, or else he hears the voice of his parents, of his friends who call him, who warn him of a danger, who appeal for his help, etc. Stimulated by these incitements, the patient answers, injures, quarrels, runs, rushes off, becomes furious, etc., all which acts tend to develop in him a boisterous condition, a state of mania.

In other circumstances he believes himself to be in prison, before a court of justice; he is accused of various crimes; he believes that he has committed them; he believes that his wife is unfaithful to him, that he is deceived by his friends; he is present at the funeral of his parents, etc. Under the weight of these distressing impressions, he is dull, restless, suspicious; he laments, he becomes terrified, he attempts to escape, sometimes even he meditates homicide or suicide; he presents, in a word, the aspect of a melancholic. Finally, in the most intense form, he believes himself chained at the foot of a scaffold, he has before him the bleeding corpses of his children, every thing is on fire, he is about to be swallowed up, etc. These appearances have astounded, appalled him, he remains motionless, in a complete state of stupor.

The Office of Lightning-Rods.—In his valuable little work on "Lightning-Rods, and how to construct them," Prof. John Phin thus states what the lightning-rod should do:

The function or office of the lightning-rod is twofold. In the first place, it acts as a means whereby the accumulated electricity existing in the atmosphere is silently drawn off, and allowed to pass into the earth, and thus prevent an explosion; and in the second, it acts as a path by which explosions, lightning-flashes, or disruptive discharges (as they are more properly called), may find their way to the earth freely, and thus be carried off without any danger of their acting with mechanical violence, as they are certain to do when made to pass through what are called non-conductors. Experience teaches us that, so long as a discharge of electricity passes off through a wire that is large enough to carry it safely, it does not cause any damage, or give rise to the exhibition of mechanical violence. A spark from the prime conductor of an electrical machine, if passed through a moderately fine wire, does not injure it; if passed through a thick card, it will pierce it; and, if passed through a small block of wood, it will rend it asunder. On the occasion of every thunder-storm, there is a large quantity of electricity to be conveyed from the clouds to the earth, through the air, which is in general a very poor conductor. This electricity always tends to pass by the easiest path, or, as electricians say, *the line of least resistance*. The resistance of any line may be lessened by various circumstances, such as the presence of hot vapors, as from chimneys, heated hay-stacks in the open field, or heated hay-mows in the barn; the existence of a line of carbonaceous matter, such as exists in a column of smoke; the presence of a tree with its leaves and sap, or of a house with its chimneys; or the fact that the air has been rendered moist by the passage of a shower of rain. So difficult is it, however, to detect the circumstances which render any particular path more easy than others, for the electricity to follow,

that we are often unable to give a reason for its following a particular course, and the action of this mighty force seems to us like a mere freak. Such ideas, are, however, entirely wrong; and we may accept most implicitly the statement that the flash will always take the easiest path, and it must be our duty to determine beforehand what this path shall be, and to make it so easy and so perfect that the resistance will not cause the electricity to produce the slightest mechanical violence.

NOTES.

THE Academy of Sciences in Bologna has announced that a prize of 1,200 lire (about $240), the "Aldini Prize," will be awarded to the author of the best scientific experimental essay on galvanism or dynamic electricity. Essays intended for the competition must be sent in between July 1, 1872, and June 30, 1874, and must be written in Italian, Latin, or French. They must be either written or printed; but, in the latter case, must not have been published previously to the two years above mentioned. Each essay is to bear a motto, and to be accompanied with an envelope stating the name of the author. They must be addressed to the Perpetual Secretary of the Academy of Sciences of the Bologna Institution.

HARVEY, the discoverer of the circulation of the blood, is at length to be honored by the erection of a national memorial. The townsmen of his native place, Folkestone, have resolved not to allow the tercentenary of his birth to pass unnoticed, and it has been decided that a bronze statue, if possible, of a very superior class, shall be erected to his memory. A committee is in progress of formation in London to assist the Folkestone committee, and public scientific bodies and individuals are being asked for aid and coöperation.

REPEATED spectroscopic measurements made last year by Profs. Zöllner and Vogel, in Germany, show that the velocity of rotation of the sun on its own axis is at the rate of 660 miles an hour.

DR. ANGUS SMITH gives a good rule for ascertaining the amount of carbonic acid in the air of houses: "Let us keep our rooms so that the air does not give a precipitate when a 10½ ounce bottle full is shaken with half an ounce of clear lime-water," a sanatory regulation which can easily be carried out.

A FRENCH doctor has recently been making some curious experiments as to the effect of alcohol on fowls. The birds took to dram-drinking with evident delight, and many an old cock consumed his bottle of wine a day, so that it became necessary to limit the allowance. They all lost flesh rapidly, more especially those which drank absinthe. Two months of absinthe-drinking was found sufficient to kill the strongest cock or hen. The fowls which indulged in brandy alone, lasted, however, four months and a half, while the wine-bibbers survived for ten months. Their crests also swelled to four times the original size, and became unnaturally red.

A GERMAN naturalist answers the question, how many eggs a hen can possibly lay, as follows: The ovary of a hen contains about 600 embryo eggs, of which, in the first year, not more than 20 are matured. The second year produces 120; the third, 135; the fourth, 114; and in the following four years the number decreases by 20 yearly. In the ninth year only 10 eggs can be expected, and thus it appears that, after the first four years, hens cease to be profitable as layers.

IT is proposed by the United States Signal Service to institute, during the present season, a series of observations, in connection with balloon ascensions, upon temperature, barometric pressure, currents, etc., in the higher atmosphere. Sergeant Schaeffer, one of the corps, has been designated for the service, and is now preparing for the work, which is to be begun in the neighborhood of Boston.

THE experiment of introducing salmon into the Delaware River, though a failure last year, through the death of the larger portion of the young fish while on their way from the hatching-houses to the river, has this year been attended with success; owing, it is said, to the hatching being done near the river, whereby transportation for long distances was avoided.

ACCORDING to Prof. Gould, electric waves travel through the Atlantic cables at the rate of between 7,000 and 8,000 miles per second; or, about half as fast as they traverse the wires suspended on telegraph-poles.

A HUNDRED thousand young shad have been put into Lake Champlain during the present season, for the purpose of determining whether they will live and multiply when confined exclusively to fresh water.

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President of the British Association for the Advancement of Science.